BANISTERIA

A JOURNAL DEVOTED TO THE NATURAL HISTORY OF VIRGINIA

Oak-Hickory Savanna at Quantico Marine Corps Base, Virginia

The flora of this rare, frequently burned community
is discussed in the lead article of this issue

Number 17 ISSN 1066-0712 2001

BANISTERIA

A JOURNAL DEVOTED TO THE NATURAL HISTORY OF VIRGINIA

ISSN 1066-0712

Published by the Virginia Natural History Society

The Virginia Natural History Society (VNHS) is a nonprofit organization dedicated to the dissemination of scientific information on all aspects of natural history in the Commonwealth of Virginia. Membership in VNHS includes a subscription to *Banisteria*. Annual dues are $15.00 (per calendar year); library subscriptions to *Banisteria* are $30.00. Subscribers/members outside the United States should add $3.00 for additional postage. Checks should be made payable to the Virginia Natural History Society. Membership dues and inquires should be directed to the Secretary-Treasurer (address, page 2); correspondence regarding *Banisteria* to one of the co-editors. *Banisteria* is a peer-reviewed journal. For additional information regarding the VNHS, including other membership categories, consult our website at: http://fwie.fw.vt.edu/vnhs/

Editorial Staff: Banisteria

Co-editors

Joseph C. Mitchell, Department of Biology
University of Richmond, Richmond, Virginia 23173

Steven M. Roble, Virginia Department of Conservation and Recreation
Division of Natural Heritage, 217 Governor Street
Richmond, Virginia 23219

Associate Editors

Richard L. Hoffman, Virginia Museum of Natural History
Martinsville, Virginia 24112

Alfred G. Wheeler, Jr., Department of Entomology
Clemson University, Clemson, South Carolina 29634

Thomas F. Wieboldt, Department of Biology
Virginia Polytechnic Institute & State University
Blacksburg, Virginia 24061

Production Consultant

Patricia A. Roble
Richmond, Virginia

Cover: Oak-hickory savanna at Quantico Marine Corps Base; photo by Gary P. Fleming.
Inner back cover: Original drawing by John Banister; provided by Joseph and Nesta Ewan.

BANISTERIA

A JOURNAL DEVOTED TO THE NATURAL HISTORY OF VIRGINIA

Number 17, 2001

Table of Contents

The Vascular Flora of Fire-Maintained Grasslands and Woodlands at Quantico Marine Corps Base, Virginia
Gary P. Fleming, Kathleen M. McCoy, and Nancy E. Van Alstine. 3

A Status Survey of Freshwater Mussel Populations in the Upper Clinch River, Tazewell County, Virginia
Jess W. Jones, Richard J. Neves, Matthew A. Patterson, Chris R. Good, and Antoinette DiVittorio. 20

Natural History of Amphibians, Reptiles, and Small Mammals in a Degraded Environment in Southeastern Virginia
Joseph C. Mitchell, A. Scott Bellows, C. Todd Georgel, and Joseph S. Ferris 31

An Update to the Survey of Macrolepidopteran Moths Near Vontay, Hanover County, Virginia
J. Christopher Ludwig 42

First Records for the Yellow Lamp Mussel (*Lampsilis cariosa*) in the Roanoke River System of Virginia
Richard L. Hoffman. 48

Loggerhead Sea Turtle Late Nesting Ecology in Virginia Beach, Virginia
Chad L. Cross, John B. Gallegos, and Florence G. James. 52

Miscellanea

Book Reviews 55
Reports 57
Instructions for Contributors 59

Virginia Natural History Society
Officers

President

Werner Wieland
Department of Biological Sciences
Mary Washington College
Fredericksburg, Virginia 22401-5358
(term expires December, 2002)

Vice President

Barbara J. Abraham
Department of Biological Sciences
Hampton University
Hampton, Virginia 23668
(term expires December, 2002)

Secretary-Treasurer

Anne C. Lund
Department of Biology
Hampden-Sydney College
Hampden-Sydney, Virginia 23943
(term expires December, 2004)

Councilors

Paul Bedell
10120 Silverleaf Terrace
Richmond, Virginia 23236
(term expires December, 2004)

Joella C. Killian
Department of Biological Sciences
Mary Washington College
Fredericksburg, Virginia 22401-5358
(term expires December, 2002)

Thomas J. McAvoy
Department of Entomology
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061
(term expires December, 2004)

Honorary Councilors

Richard L. Hoffman
Michael Kosztarab

Banisteria, Number 17, 2001
© 2001 by the Virginia Natural History Society

The Vascular Flora of Fire-Maintained Grasslands and Woodlands at Quantico Marine Corps Base, Virginia

Gary P. Fleming, Kathleen M. McCoy, and Nancy E. Van Alstine

Virginia Department of Conservation and Recreation
Division of Natural Heritage
217 Governor Street
Richmond, Virginia 23219

INTRODUCTION

In 1998, the Virginia Department of Conservation and Recreation's Division of Natural Heritage (DCR-DNH) initiated a survey of flora and fauna at Quantico Marine Corps Base (MCBQ), Virginia, for the Department of the Navy. This study supported the need of military installations to inventory, monitor, and manage for biodiversity. One component of the project was to inventory the fire-maintained vegetation in Training Area 9 and to produce a list of the plant species present; another was the documentation of any rare plants or natural communities at the site. The vegetation of this site, consisting of savanna-like woodlands and grasslands, is unusual because of the long-term influences of frequent burning, and is replicated in Virginia only at similar sites within Forts A.P. Hill and Pickett.

STUDY AREA

The study area is a highly restricted military training facility that is not open to public access. It is located approximately 50 km SW of Washington, D.C., at the convergence of Fauquier, Prince William, and Stafford counties (Fig. 1). Physiographically, the site is situated in the easternmost portion of the Piedmont Plateau, about 16 km west of the Fall Line marking the boundary between the Piedmont and Coastal Plain. Mean annual temperature is 14.1E C (57.3E F) and mean annual precipitation is 92.1 cm (36.3 in) at Manassas, 22 km north of the study area (Elder, 1989). The area is underlain by metamonzogranite (Rader & Evans, 1993) and topography consists predominantly of undulating to gently rolling uplands, with a few short, steep slopes abutting Canon Creek and its major tributaries. Elevation ranges from 60 m to 130 m. Soils of the uplands are gritty silt loams of the Goldvein series (Petro, 1956). Several tributaries forming the headwaters of Canon Creek and Dorrells Creek originate in the study area and contain boggy areas with abundant groundwater discharge and organic-rich soils. Larger, more marshy wetlands, including several beaver ponds, occur downstream along Canon Creek and its largest tributaries.

The Quantico Marine Corps Base was established as a combat training facility in 1917, and Training Area 9 has been used for artillery training since World War II. The use of incendiary ammunition, particularly illumination rounds, has subjected parts of this landscape to a regime of random but frequent wildfires of variable intensity. The presence of hazardous unexploded ordnance and metal contamination of forest stands precludes any additional land uses such as timber management.

METHODS

Botanical

Field work by DCR-DNH staff for the grassland inventory began in May 1998 and was completed in August 1999. Because Training Area 9 is a potentially dangerous area, DCR-DNH staff were escorted by Explosive Ordnance Disposal (EOD) personnel, and field visits were limited by MCBQ to a maximum of one visit per 30 days. Evenly spaced trips throughout the growing season were attempted in 1998, and visits were made on the following dates: May 28, July 17, August 24, and October 19. In 1999 three visits (April 19, May 25, and August 24) were made to fill both chronological and landscape data gaps.

A major limitation of this study was that the surveyors were required to walk behind EOD personnel at all times for safety reasons. Discrete areas could be more freely and thoroughly surveyed only after EOD

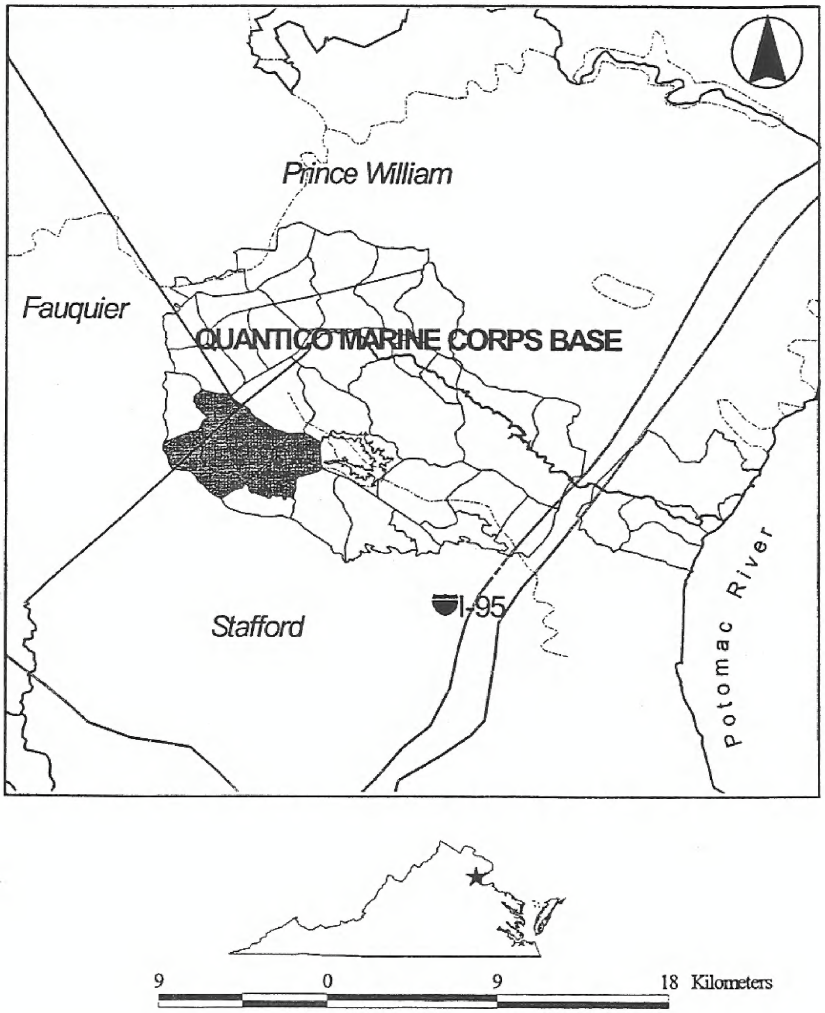


Fig. 1. Location of the study site (shaded area) within Quantico Marine Corps Base, Virginia.

personnel determined them to be free of hazardous ordnance. As a result, the inventory was conducted by walking transects across major environmental gradients, with more intensive inventory targeted in the highest quality, most productive habitats. The latter included not only the open upland grasslands but also savanna-like woodlands and boggy and marshy wetlands. Surveys were conducted primarily within Training Area 9A, but surveys were also conducted in a frequently burned area in Training Area 9B and in a recently burned area in Training Area 9D. All vascular plant taxa were identified and recorded as they were encountered. Because of the rigorous logistical and time constraints, it was not practical to voucher all taxa in the study area. However, voucher specimens were collected to verify some field identifications and to document all new county records. The highest quality areas were surveyed during multiple visits to ensure that ephemeral plants were captured. Nomenclature follows Kartesz (1999).

When rare plant occurrences were located, additional data were collected following standard DCR-DNH methodology. These data included the date found, population boundaries and concentrations within those boundaries, approximate number of individuals, reproductive and phenological status, and species viability. Habitat factors such as moisture, light, and associated species, and apparent immediate or long-term threats to the rare species populations were also noted.

Natural Communities

Compositional and environmental data were collected from six plots, with two plots placed in representative stands of each of three broad community types: grasslands, savanna/woodlands, and bogs. In addition to providing data on vegetation structure and associated environmental conditions, plot sampling requires an intensive inventory of all flora within the plot area and therefore captures taxa that may be overlooked during walking surveys. Plots were sampled using the relève method (*sensu* Peet et al., 1998), with 400 m^2 plots established in woodland vegetation and 100 m^2 plots in grassland and bog vegetation. Within each plot, all vascular plants were recorded and the total cover of each taxon was estimated as a vertical projection onto the plot area. In addition, the cover of woody species was estimated in six vertical height strata, and the diameters of all woody stems ≥ 2.5 cm DBH were measured. A standard set of environmental data, including slope, slope shape, aspect, surface substrate cover, topographic position, soil drainage class, and soil moisture regime, were measured or estimated. In addition, soil samples were collected from the top 10 cm of mineral soil and analyzed for pH, phosphorus, exchangeable cations, and extractable micronutrients by the Soil Testing and Plant Analysis Laboratory at Virginia Polytechnic Institute and State University.

RESULTS

Flora

During the 1998 and 1999 field visits, 350 taxa were recorded during the floristic inventory. Two additional species were added from a list that had been compiled by DCR-DNH personnel during a brief visit to the study area in 1991, bringing the total to 352 (Virginia Department of Conservation and Recreation, 1992). The list of the flora of the fire-maintained grasslands and woodlands at Quantico, containing the scientific name and habitats in which each taxon was found, is presented in Appendix 1. The flora of these frequently burned areas falls within 74 families. Taxa of four families (Asteraceae: 50 taxa; Poaceae: 40 taxa; Cyperaceae: 33 taxa; and Fabaceae: 23 taxa) comprise 40 % of the total flora. Other well-represented families include Rosaceae (14 taxa) and Fagaceae (12 taxa).

Forty-two new distribution records for Fauquier, Prince William, or Stafford counties were documented with collections. Voucher specimens for these records are deposited at the George Mason University Herbarium (GMUF), and the records will be incorporated into the next edition of the *Atlas of the Virginia Flora* (Harvill et al., 1992). County records are indicated in Appendix 1.

Rare Species

Two state rare species were found at Quantico Marine Corps Base during the Training Area 9 inventory. A population of *Carex buxbaumii* (Buxbaum's sedge), a sedge with a circumboreal distribution, was located in a boggy swale near the northern edge of the study area. This species is very rare in Virginia, with 19 known occurrences in the state. The population occupies viable habitat, with thousands of sterile culms and < 100 fruiting culms in a dense colony covering 30-40 m^2 . The fruiting culms were obvious on the visit of 28 May 1998, and the fruits were shed by 17 July 1998. The habitat is a boggy sphagnous swale subject to frequent fires. The vegetation is predominantly herbaceous, with scattered shrubs. The most abundant associated species include *Osmunda cinnamomea, Osmunda regalis* var. *spectabilis, Thelypteris palustris* var. *pubescens, Carex emoryi*, and *Solidago rugosa.*

The other state-rare species, *Asclepias rubra* (red milkweed), occurs in the same swale. The population is relatively small, but apparently viable, consisting of approximately 20 individuals scattered over a 2 ha area. Plants were of average vigor and were flowering on 17 July 1998, and fruiting on 24 August 1998. Characteristic associates of *A. rubra* at this site include *Alnus serrulata, Carex stricta, Carex folliculata, Osmunda cinnamomea*, and *Melanthium virginicum.*

Significant Natural Communities

During the course of the project, DCR-DNH ecologists identified seven occurrences of three rare, fire-maintained natural community types: Coastal Plain/Piedmont Seepage Bog (three occurrences), Acidic Oak-Hickory Woodland/ Savanna (two occurrences), and Piedmont Prairie (two occurrences). Community nomenclature follows Fleming et al. (2001).

Coastal Plain / Piedmont Seepage Bog

These scrubby to herbaceous wetlands occur in areas of groundwater discharge at the headwaters of three streams in the study area (Fig. 2). Soils of these boggy habitats are saturated year-round and are strongly acidic (mean pH = 4.1), with low base-cation levels. Shrubs and herbaceous species occur in patch-mosaics, with shrub density and stature varying with the interval since the last fire. Characteristic shrubs include *Alnus serrulata*, *Magnolia virginiana*,

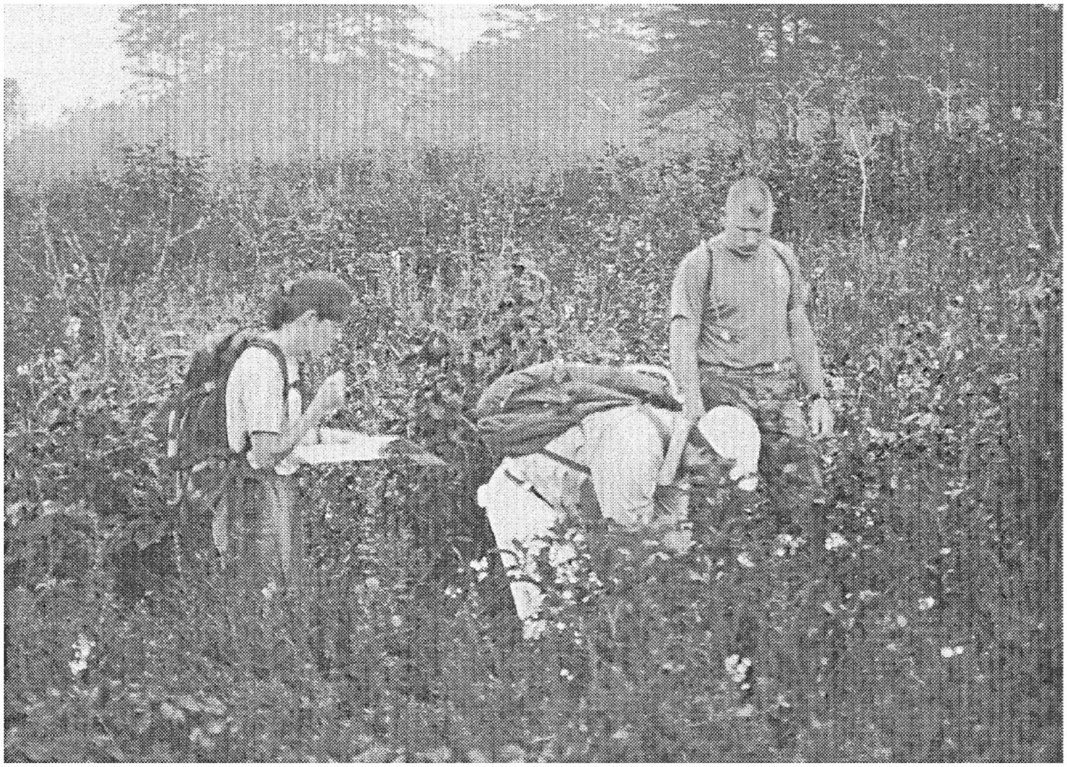


Fig. 2. Natural Heritage ecologists and EOD escort examine a frequently burned bog at Quantico Marine Corps Base. Photo by Robert T. Stamps.

Toxicodendron vernix, and *Viburnum nudum* var. *nudum*. Characteristic herbaceous plants include *Andropogon glomeratus*, *Calamagrostis coarctata*, *Carex folliculata*, *Eupatorium pilosum*, *Juncus canadensis*, *Osmunda cinnamomea*, *Oxypolis rigidior*, *Rhynchospora capitellata*, *Rhynchospora gracilenta*, *Saccharum giganteum*, *Scleria muehlenbergii*, *Solidago rugosa*, *Thelypteris palustris* var. *pubescens*, and *Xyris torta*. The state-rare plants *Asclepias rubra* and *Carex buxbaumii* are associated with this community type.

Acidic Oak-Hickory Woodland / Savanna

A large occurrence (> 50 ha) of this vegetation type is located in the western part of the study area, and consists of a variable mosaic of very open to semi-closed woodlands and grasslands with scattered, scrubby trees (Fig. 3). A smaller occurrence is located in the southeastern part of the site. Habitats supporting this community type are dry upland slopes and ridges with strongly acidic (mean pH = 4.5), nutrient-poor, sandy loam soils. Most of the tree canopy is contributed by deciduous species, but some areas have scattered stands of *Pinus virginiana* and *Pinus taeda*. Dominant trees include *Quercus falcata*, *Quercus alba*, *Quercus stellata*, and *Carya alba*. The understory and shrub layers are normally very sparse but may contain young sprouts of the canopy species as well as scattered patches of *Vaccinium* spp. and *Gaylussacia baccata*. The herbaceous layer is rich in graminoids, particularly *Schizachyrium scoparium*, *Danthonia spicata*, *Dichanthelium* spp., and *Carex pensylvanica*, giving a savanna-like appearance to many of the stands. Characteristic forbs include *Lespedeza frutescens*, *Sericocarpus asteroides*, *Symphyotrichum dumosum* (= *Aster dumosus*), and *Solidago* spp.

Piedmont Prairie

Two sizeable but fragmented occurrences (> 30 ha and > 20 ha) of this vegetation occur in patch-mosaics with the oak-hickory woodlands on dry to moderately moist uplands in the western and southeastern portions of the study area. This community type is a dense grassland composed entirely of herbaceous species, or

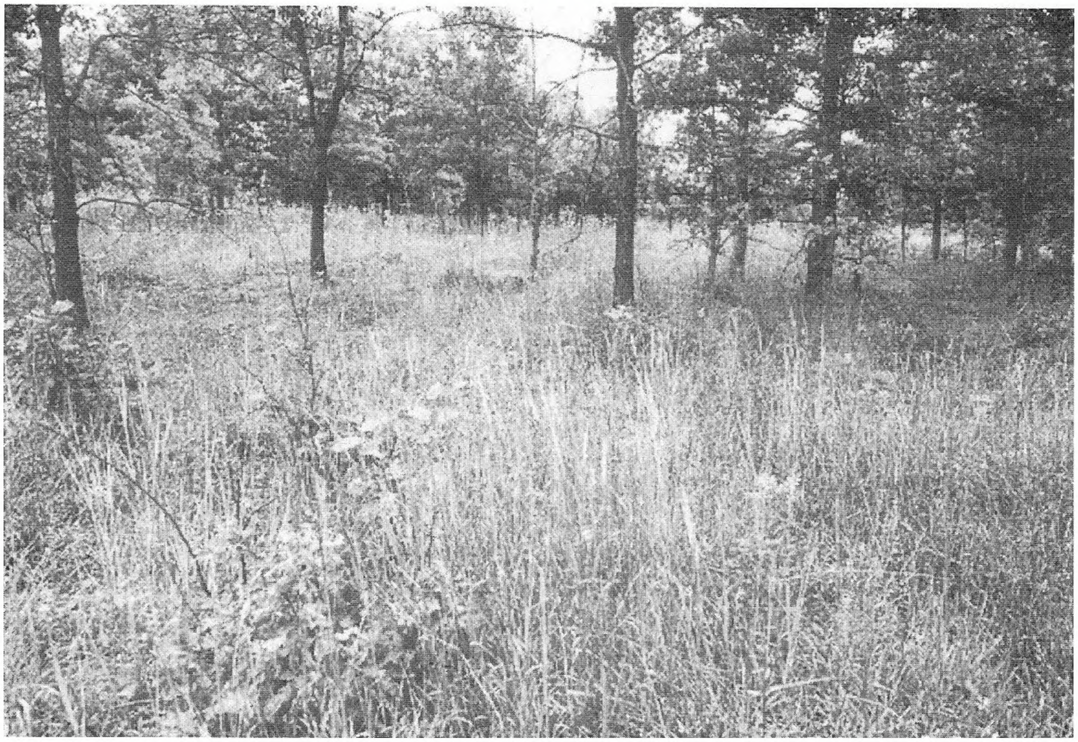


Fig. 3. Frequently burned oak-hickory savanna at Quantico Marine Corps Base. Photo by Gary P. Fleming.

nearly so; a few scattered, shrubby woody plants sometimes occur. The dominant grasses, contributing >50% of the cover in any given stand, are *Schizachyrium scoparium* and *Sorghastrum nutans*. Both species almost always occur together, with the latter becoming more abundant as soil moisture increases. Characteristic associates include *Agalinis tenuifolia*, *Aletris farinosa*, *Antennaria neglecta*, *Aristida purpurascens*, *Eupatorium hyssopifolium* var. *hyssopifolium*, *Liatris squarrosa*, *Pycnanthemum tenuifolium*, *Scleria pauciflora*, *Sericocarpus linifolius*, *Solidago nemoralis*, and *Symphyotrichum dumosum* (= *Aster dumosus*). This community type is quite similar to some of the mid- and tall-grass prairies of the Midwestern United States, but has many associate species found primarily or exclusively in the eastern states.

DISCUSSION

Flora

The flora of the study area's fire-maintained grasslands and woodlands largely reflects the phytogeography of Virginia's northern Piedmont physiographic province, with most taxa (e.g., *Acer rubrum*, *Rhus copallinum*, *Schizachyrium scoparium*, *Solidago juncea*, *Carex stricta*, *Vaccinium pallidum*, *Osmunda cinnamomea*, and many others) widely distributed in Virginia.

A smaller group of taxa is representative of a more restricted Virginia distribution but still characteristic of the Piedmont. Some of those distributed primarily in the Piedmont and Coastal Plain include *Toxicodendron vernix*, *Eupatorium hyssopifolium* (both var. *hyssopifolium* and var. *laciniatum*), *Eupatorium rotundifolium*, *Solidago pinetorum*, *Woodwardia areolata*, *Viburnum nudum* var. *nudum*, *Saururus cernuus*, *Amelanchier canadensis*, *Saccharum giganteum, Polygala incarnata, Dichanthelium scoparium, Pinus taeda*, *Linum medium* var. *texanum*, *Quercus phellos*, *Helianthus atrorubens*, *Sericocarpus linifolius*, *Andropogon gyrans*, and *Lobelia puberula*. *Liatris squarrosa*, *Cirsium pumilum*, and *Rudbeckia fulgida* are taxa with Virginia distributions mostly restricted to the Piedmont. *Platanthera ciliaris*, on the other hand, is rare in the Piedmont and more common in the Coastal Plain and mountains.

While this area of MCBQ falls within the Piedmont, it lies only about 16 km west of the Coastal Plain and therefore the presence of taxa most common in the Coastal Plain is not surprising. Some of these include *Asclepias rubra*, *Xyris torta*, *Hypericum crux-andreae*, *Rhynchospora gracilenta*, *Magnolia virginiana*, *Lyonia mariana*, and *Andropogon glomeratus*. Most of these Coastal Plain taxa are associated with seepage bogs, a community type primarily associated with the Coastal Plain.

A few taxa recorded in this inventory are more common in Virginia's montane Blue Ridge or Ridge and Valley physiographic provinces than in the Piedmont. These include *Pinus rigida*, *Antennaria neglecta*, *Cirsium muticum, Carex emoryi*, and *Juncus subcaudatus*. A particularly noteworthy discovery during this study was *Quercus ilicifolia*. This oak is almost entirely restricted to the mountains in Virginia, with a few small, local populations in the western Piedmont counties. Our collection from Quantico (*Fleming, McCoy & Coulling 14604*) represents a Stafford County record and the population that is farthest removed from this species' normal montane habitats in Virginia.

Although overwhelmingly composed of native taxa, the flora does include some exotic taxa, primarily in the ruderal habitats such as roadsides and wildlife food plots. Only rarely do exotics occur and persist in frequently burned habitats with dense cover of native grasses and forbs. *Lespedeza bicolor*, a shrub introduced for wildlife, is locally invasive and appears to thrive under a burning regime. Exotic species are denoted in Appendix 1.

Significant Natural Communities

Active fire-influenced ecosystems were once widely distributed over the entire southeastern Coastal Plain and parts of the Piedmont Plateau (Vogl, 1973; Christensen, 1981; Christensen 1988). In the pre-Columbian era, lightning strikes and the extensive employment of fire as a hunting tool by Native Americans were sources of major wildfires. As late as the early decades of the 20th century, careless logging operations and coal-burning railroad engines were common instigators of fires that, in the absence of adequate resources to fight them, often burned out of control over large areas (Dean 1969). Due to efficient and widespread fire reduction since the mid-20th century, however, fire-dependent ecosystems have been nearly extirpated statewide. Exceptions are limited to the military base artillery training areas at Fort Pickett, Fort A.P. Hill, and Quantico Marine Corps Base, where frequent incendiary burns maintain specialized habitat conditions and vegetation assemblages, perhaps simulating pre-settlement fire regimes.

Although additional data and analyses will be required to formally classify the fire-influenced communities at Quantico, it appears that the Oak-Hickory Woodland/Savanna and Piedmont Prairie are globally rare community types that are now restricted to Quantico and Fort Pickett, since no other sites in the Atlantic Piedmont have the requisite disturbance regimes in place. The Quantico bogs may be somewhat less rare because of the persistence of similar communities in a number of sites along the Coastal Plain from New Jersey to North Carolina.

ACKNOWLEDGMENTS

This project was funded by the Department of the Navy, Engineering Field Activity Chesapeake. We thank Robert T. Stamps of the Natural Resources and Environmental Affairs Branch (NREA) at Quantico Marine Corps Base for managing project logistics and for use of the photograph in Fig. 2. We also thank EOD personnel for guiding us safely through the impact area. Gerald O'Hara of NREA provided the GIS boundary coverages used in Fig. 1 and David Boyd (DNH) assisted in developing the map. DNH staff who assisted in data collection were Steven E. Killefer, Philip P. Coulling, Dean P. Walton, and Anne C. Chazal.

LITERATURE CITED

Christensen, N. L. 1981. Fire regimes in Southeastern ecosystems. Pp. 112-136 *In* H. A. Mooney, T. M. Bonnicksen, N. L. Christensen, J. E. Lotan, & W. A. Reinsers (eds.). Fire Regimes and Ecosystem Properties. USDA Forest Service General Technical Report WO-26.

Christensen, N. L. 1988. Vegetation of the Southeastern Coastal Plain. Pp. 317-363 *In* M. G. Barbour & W. D. Billings (eds.). North American Terrestrial Vegetation. Cambridge University Press, New York, NY.

Dean, G. W. 1969. Forests and forestry in the Dismal Swamp. Virginia Journal of Science 20: 166-173.

Elder, J. H., Jr. 1989. Soil Survey of Prince William County, Virginia. U.S. Department of Agriculture, Soil Conservation Service, Washington, D.C. 245 pp.

Fleming, G. P., P. P. Coulling, D. P. Walton, K. M. McCoy, & M. R. Parrish. 2001. The Natural Communities of Virginia: Classification of Ecological Community Groups. First Approximation. Natural

Heritage Technical Report 01-1. Virginia Department of Conservation and Recreation, Division of Natural Heritage, Richmond, VA. 76 pp.

Harvill, A. M., Jr., T. R. Bradley, C. E. Stevens, T. F. Wieboldt, D. M. E. Ware, D. W. Ogle, G. W. Ramsey, & G. P. Fleming. 1992. Atlas of the Virginia Flora. Virginia Botanical Associates, Burkeville, VA. 144 pp.

Kartesz, J. T. 1999. A Synonymized Checklist and Atlas with Biological Attributes for the Vascular Flora of the United States, Canada, and Greenland. First Edition. *In* Kartesz, J. T., & C. A. Meacham. Synthesis of the North American Flora, Version 1.0. CD-ROM. North Carolina Botanical Garden, Chapel Hill, NC.

Peet, R. K., T. R. Wentworth, & P. S. White. 1998. A flexible, multipurpose method for recording vegetation composition and structure. Castanea 63: 262-274.

Petro, J. H. 1956. Soil Survey of Fauquier County, Virginia. U. S. Department of Agriculture, Soil Conservation Service, Washington, D.C. 231 pp.

Rader, E. K., & H. H. Evans (eds.). 1993. Geologic map of Virginia – expanded explanation. Virginia Department of Mines, Minerals, and Energy, Division of Mineral Resources, Charlottesville, VA. 80 pp.

Virginia Department of Conservation and Recreation. Division of Natural Heritage. 1992. A Natural Heritage Inventory, Marine Corps Combat Development Command, Stafford, Prince William, and Fauquier Counties, Virginia. Natural Heritage Technical Report 92-25, Virginia Department of Conservation and Recreation, Division of Natural Heritage, Richmond, VA. 41 pp. plus appendices.

Vogl, R. J. 1973. Fire in Southeastern grasslands. Pp. 175-198 *In* Annual Proceedings, Tall Timbers Fire Ecology Conference, Number 12, June 8-9, 1972. Tall Timbers Research Station, Tallahassee, FL.

APPENDIX 1. FLORA OF THE FIRE-MAINTAINED GRASSLANDS AND WOODLANDS AT QUANTICO MARINE CORPS BASE, VIRGINIA

Taxa recorded in 1998-1999 by DCR-DNH. Nomenclature follows Kartesz (1999); synonymy has been provided for treatments that diverge significantly from more traditional nomenclature. The table is arranged alphabetically by family. Several taxa which were recorded by DCR-DNH personnel in 1991 during a brief visit and are likely still present have been marked here with an asterisk (*). Exotic taxa are marked with a plus sign (+). Vouchered taxa are indicated by a "V" and the counties of new records are given in the third column. **Habitat key:** 1-upland grasslands (Piedmont Prairie). 2-oak-hickory woodland /savannas. 3-boggy wetlands. 4-marshy wetlands. 5-ruderal habitats (roadsides, parking areas, wildlife plots, etc.).

Scientific Name	**Habitat**	**County Record**
ACERACEAE		
Acer rubrum L.	1, 2, 3, 4	
ACORACEAE		
Acorus calamus L.	4	
ALISMATACEAE		
Alisma subcordatum Raf.	4	
Sagittaria latifolia Willd.	4	
ANACARDIACEAE		
Rhus copallinum L.	1, 2, 3	
Rhus glabra L.	1, 5	
Toxicodendron radicans (L.) Kuntze	2, 4, 5	
Toxicodendron vernix (L.) Kuntze	3	

Scientific Name	**Habitat**	**County Record**
APIACEAE		
Angelica venenosa (Greenway) Fern.	2	
Daucus carota L. * +	5	
Oxypolis rigidior (L.) Raf.	3	
Sanicula canadensis L.	2	
APOCYNACEAE		
Apocynum cannabinum L.	1, 2, 5	
AQUIFOLIACEAE		
Ilex opaca Ait.	2	
ARACEAE		
Arisaema triphyllum (L.) Schott	3, 4	
Symplocarpus foetidus (L.) Salisb. *ex* Nutt.	3	
ARALIACEAE		
Aralia spinosa L.	2	
ASCLEPIADACEAE		
Asclepias amplexicaulis Sm.	1	
Asclepias incarnata L. ssp. *pulchra* (Ehrh. *ex* Willd.) Woods.	3, 4	
Asclepias rubra L.	3	V, Fauquier; V, Prince William
Asclepias tuberosa L.	2	
Asclepias viridiflora Raf.	1	
ASTERACEAE		
Achillea millefolium L. var. *occidentalis* DC.	1, 2	
Ambrosia artemisiifolia L.	5	
Antennaria neglecta Greene	1	
Antennaria plantaginifolia (L.) Richards.	2	
Bidens aristosa (Michx.) Britt.	3, 4, 5	
= *Bidens polylepis* Blake		
Centaurea biebersteinii DC. +	5	
= *Centaurea maculosa auct. non* Lam.		
Chrysopsis mariana (L.) Ell.	1, 2	
Cirsium discolor (Muhl. *ex* Willd.) Spreng.	1, 5	
Cirsium muticum Michx.	3	
Cirsium pumilum (Nutt.) Spreng.	1	
Coreopsis tripteris L.	2, 3	
Coreopsis verticillata L.	1, 2	
Doellingeria umbellata (P. Mill.) Nees	3	V, Fauquier
= *Aster umbellatus* P. Miller		
Erechtites hieraciifolia (L.) Raf. *ex* DC	1, 2, 5	
Erigeron annuus (L.) Pers.	1, 5	
Erigeron strigosus Muhl. *ex* Willd.	1, 5	
Eupatorium album L.	1, 5	
Eupatorium fistulosum Barratt	3, 4	
Eupatorium hyssopifolium L.var. *hyssopifolium*	1, 2, 3	
Eupatorium hyssopifolium L.var. *laciniatum* Gray	2	
Eupatorium perfoliatum L.	3, 4	
Eupatorium pilosum Walt.	1, 2, 3	

Scientific Name	**Habitat**	**County Record**
Eupatorium rotundifolium L. var. *ovatum* (Bigelow) Torr.	1, 2	
Eupatorium rotundifolium L. var. *rotundifolium*	1, 2, 3	
Euthamia graminifolia (L.) Greene	3	
Helianthus atrorubens L.	1	
Helianthus giganteus L.	3	
Hieracium gronovii L.	1, 2	
Hieracium venosum L.	2	
Ionactis linariifolius (L.) Greene = *Aster linariifolius* L.	1	V, Prince William
Lactuca canadensis L.	1	
Leucanthemum vulgare Lam. +	2, 5	
Liatris squarrosa (L.) Michx.	1, 2	
Packera anonyma (Wood) W.A. Weber & A. Löve = *Senecio anonymus* Wood	1	
Pseudognaphalium obtusifolium (L.) Hilliard & Burtt = *Gnaphalium obtusifolium* L.	1	
Rudbeckia fulgida Ait.	1	
Rudbeckia hirta L.	1, 5	
Rudbeckia laciniata L.	3, 4	
Sericocarpus asteroides (L.) B.S.P. = *Aster paternus* Cronq.	2	
Sericocarpus linifolius (L.) B.S.P. = *Aster solidagineus* Michx.	1, 2	
Solidago bicolor L.	1, 2	
Solidago erecta Pursh	2	
Solidago juncea Ait.	1, 2	V
Solidago nemoralis Ait.	1, 2	
Solidago pinetorum Small	1	V, Fauquier
Solidago rugosa P. Mill.	3, 4	
Symphyotrichum dumosum (L.) Nesom = *Aster dumosus* L.	1, 2, 3	
Symphyotrichum lateriflorum (L.) A.& D. Löve = *Aster lateriflorus* (L.) Britt.	1, 2, 3, 4, 5	
Symphyotrichum puniceum (L.) A.& D. Löve = *Aster puniceus* L.	3, 4	
Symphyotrichum undulatum (L.) Nesom = *Aster undulatus* L.	1, 2	
Vernonia noveboracensis (L.) Michx.	3, 4	
BALSAMINACEAE		
Impatiens capensis Meerb.	4	
BETULACEAE		
Alnus serrulata (Ait.) Willd.	3, 4	
Betula nigra L.	4	
Corylus americana Walt.	2, 4	
Ostrya virginiana (P. Mill.) K. Koch	2	
BLECHNACEAE		
Woodwardia areolata (L.) T. Moore *	3	

Scientific Name	**Habitat**	**County Record**
BRASSICACEAE		
Arabidopsis thaliana (L.) Heynh. +	1, 5	
Barbarea vulgaris Ait. f. +	2, 5	
Cardamine hirsuta L. +	5	
CAMPANULACEAE		
Lobelia inflata L.	1, 2, 5	
Lobelia puberula Michx.	3	
Lobelia spicata Lam. var. *scaposa* McVaugh	1, 2	
Triodanis perfoliata (L.) Nieuwl.	1, 3	
CAPRIFOLIACEAE		
Lonicera japonica Thunb. +	1, 2	
Sambucus nigra L. ssp. *canadensis* (L.) R. Bolli = *Sambucus canadensis* L.	3, 4	
Viburnum acerifolium L.	2	
Viburnum nudum L. var. *nudum*	3	V, Fauquier
Viburnum prunifolium L.	2	
Viburnum recognitum Fern.	4	
CISTACEAE		
Lechea pulchella Raf.	1, 2	V, Stafford
Lechea racemulosa Michx.	1, 2	
CLUSIACEAE		
Hypericum crux-andreae (L.) Crantz	2	V, Prince William
Hypericum gentianoides (L.) B.S.P.	1, 2	
Hypericum hypericoides (L.) Crantz ssp. *multicaule* (Michx. *ex* Willd.) Robson	1, 2	
Hypericum mutilum L.	3	
Hypericum punctatum Lam.	1, 2	
Triadenum virginicum (L.) Raf.	3	
CONVOLVULACEAE		
Ipomoea pandurata (L.) G.F.W. Mey.	1, 2	
CORNACEAE		
Cornus florida L.	1, 2	
Nyssa sylvatica Marsh.	2	
CUSCUTACEAE		
Cuscuta compacta Juss. *ex* Choisy	3	V, Prince William
Cuscuta gronovii Willd. *ex* J.A. Schultes	4	
CYPERACEAE		
Bulbostylis capillaris (L.) Kunth *ex* C.B. Clarke	2	
Carex atlantica Bailey ssp. *atlantica*	3	V
Carex buxbaumii Wahlenb.	3	V, Prince William
Carex crinita Lam. var. *crinita*	3, 4	
Carex debilis Michx. var. *debilis*	3	
Carex emoryi Dewey	3	V
Carex festucacea Schkuhr *ex* Willd.	4	

Scientific Name	**Habitat**	**County Record**
Carex folliculata L.	3	V, Fauquier
Carex hirsutella Mackenzie	1, 2	
Carex intumescens Rudge	3	
Carex laevivaginata (Kukenth.) Mackenzie	4	
Carex lurida Wahlenb.	3, 4	
Carex pensylvanica Lam.	2	
Carex scoparia Schkuhr *ex* Willd.	4	
Carex stricta Lam.	3, 4	
Carex swanii (Fern.) Mackenzie	1, 3	
Carex tribuloides Wahlenb. var. *tribuloides*	3, 4	
Cyperus echinatus (L.) Wood	1	
Cyperus strigosus L.	3, 4	
Dulichium arundinaceum (L.) Britt.	4	
Eleocharis obtusa (Willd.) J.A. Schultes	3, 4	
Eleocharis tenuis (Willd.) J.A. Schultes	3	V
Rhynchospora capitellata (Michx.) Vahl	3	
Rhynchospora globularis (Chapman) Small	3	V, Fauquier
Rhynchospora glomerata (L.) Vahl	3	
Rhynchospora gracilenta Gray	3	V, Fauquier; V, Prince William
Schoenoplectus purshianus (Fern.) M.T. Strong	4	
Scirpus cyperinus (L.) Kunth	3, 4	
Scirpus georgianus Harper	3	
Scirpus polyphyllus Vahl	3	
Scleria muehlenbergii Steud.	3	V, Fauquier; V, Prince William
Scleria pauciflora Muhl. *ex* Willd.	1, 2	V
Scleria triglomerata Michx.	3	V
DENNSTAEDTIACEAE		
Dennstaedtia punctilobula (Michx.) T. Moore	2	
Pteridium aquilinum (L.) var. *latiusculum* (Desv.) Underwood *ex* Heller	2, 3	
DIOSCOREACEAE		
Dioscorea quaternata J.F. Gmel.	3	
DRYOPTERIDACEAE		
Onoclea sensibilis L	3	
EBENACEAE		
Diospyros virginiana L.	2	
ELAEAGNACEAE		
Elaeagnus umbellata Thunb. var. *parvifolia* (Royle) Schneid. +	5	
ERICACEAE		
Gaylussacia baccata (Wangenh.) K. Koch	2	
Lyonia ligustrina (L.) DC. var. *ligustrina*	3	V
Lyonia mariana (L.) D. Don	3	
Rhododendron viscosum (L.) Torr.	3	V
Vaccinium corymbosum L.	1, 2, 3	
Vaccinium formosum Andr.	2	

Scientific Name	**Habitat**	**County Record**
Vaccinium pallidum Ait.	2	
Vaccinium stamineum L.	2	
EUPHORBIACEAE		
Euphorbia corollata L.	1, 2	
FABACEAE		
Apios americana Medik.	3, 4	
Baptisia tinctoria (L.) R. Br. *ex* Ait. f.	1, 2	
Chamaecrista fasciculata (Michx.) Greene var. *fasciculata*	1, 4, 5	
Chamaecrista nictitans (L.) Moench	1	
Crotalaria sagittalis L.	1	
Desmodium ciliare (Muhl. *ex* Willd.) DC.	1, 2	
Desmodium laevigatum (Nutt.) DC.	2	
Desmodium marilandicum (L.) DC.	1, 2	
Desmodium nuttallii (Schindl.) Schub.	2	
Desmodium paniculatum (L.) DC.	1, 2	
Desmodium perplexum Schub.	1, 2	
Desmodium rotundifolium DC.	2	
Galactia volubilis (L.) Britt.	1, 2	
Lespedeza bicolor Turcz. +	5	
Lespedeza cuneata (Dum.-Cours.) G. Don +	3, 5	
Lespedeza frutescens (L.) Hornem. = *Lespedeza intermedia* (S. Wats.) Britt.	2	
Lespedeza procumbens Michx.	2	
Lespedeza repens (L.) W. Bart.	2	
Lespedeza virginica (L.) Britt.	1, 2	
Melilotus officinalis (L.) Lam. + (Includes *Melilotus albus* Medik.)	5	
Robinia pseudoacacia L.	1, 5	
Strophostyles umbellata (Muhl. *ex* Willd.) Britt.	1	
Stylosanthes biflora (L.) B.S.P.	2	
FAGACEAE		
Castanea pumila (L.) P. Mill.	1	
Quercus alba L.	2	
Quercus coccinea Muenchh.	2	
Quercus falcata Michx.	2	
Quercus ilicifolia Wangenh.	1, 2	V, Stafford
Quercus marilandica Muenchh.	2	
Quercus muehlenbergii Engelm.	2	
Quercus phellos L.	2	
Quercus prinus L.	2	
Quercus rubra L.	2	
Quercus stellata Wangenh.	2	
Quercus velutina Lam.	2	
GENTIANACEAE		
Gentiana villosa L.	2, 3	V, Prince William
Sabatia angularis (L.) Pursh	1	

Scientific Name	**Habitat**	**County Record**
IRIDACEAE		
Sisyrinchium angustifolium P. Mill.	3	
Sisyrinchium mucronatum Michx.	1	
JUGLANDACEAE		
Carya alba (L.) Nutt. *ex* Ell.	2	
= *Carya tomentosa* (Lam. *ex* Poir.) Nutt.		
Carya glabra (P. Mill.) Sweet	2	
JUNCACEAE		
Juncus acuminatus Michx.	3	
Juncus biflorus Ell.	3	
Juncus canadensis J. Gay *ex* Laharpe	3, 4	V
Juncus debilis Gray	3	V, Fauquier
Juncus dichotomus Ell.	3	V
Juncus effusus L. var. *pylaei* (Laharpe) Fern. & Wieg.	3	
Juncus effusus L. var. *solutus* Fern. & Wieg.	3	
Juncus scirpoides Lam.	3	
Juncus subcaudatus (Engelm.) Coville & Blake	3	
Luzula bulbosa (Wood) Smyth & Smyth	1	V, Fauquier
Luzula echinata (Small) F.J. Herm.	1	V
LAMIACEAE		
Clinopodium vulgare L.	1	
Lycopus virginicus L.	3, 4	
Prunella vulgaris L. +	1, 2, 5	
Pycnanthemum tenuifolium Schrad.	1, 2, 3	
Salvia lyrata L.	1, 5	
Scutellaria elliptica Muhl. *ex* Spreng.	1, 2	
Scutellaria integrifolia L.	1	
Trichostema dichotomum L.	1, 2	
LAURACEAE		
Sassafras albidum (Nutt.) Nees	2, 3	
LILIACEAE		
Aletris farinosa L.	1, 2, 3	V, Fauquier
Allium vineale L. +	5	
Hypoxis hirsuta (L.) Coville	2	
Lilium superbum L.	3	V, Prince William
Maianthemum racemosum (L.) Link	2	
Melanthium virginicum L.	3	V, Prince William
Uvularia perfoliata L.	2, 3	
Uvularia sessilifolia L.	2	
LINACEAE		
Linum medium (Planch.) Britt var. *texanum* (Planch.) Fern.	1, 2	
Linum striatum Walt.	3	V, Stafford
MAGNOLIACEAE		
Magnolia virginiana L.	3	V, Fauquier

Scientific Name	**Habitat**	**County Record**
MELASTOMATACEAE		
Rhexia virginica L.	3	
NYMPHAEACEAE		
Nuphar lutea (L.) Sm.	4	
OLEACEAE		
Chionanthus virginicus L.	3	
ONAGRACEAE		
Ludwigia alternifolia L.	4	
Ludwigia palustris (L.) Ell.	4	
Oenothera fruticosa L.	1, 5	
ORCHIDACEAE		
Cypripedium acaule Ait. Pink	2	
Platanthera ciliaris (L.) Lindl.	3	V, Prince William
Platanthera clavellata (Michx.) Luer	3	
Spiranthes cernua (L.) L.C. Rich.	3	V, Prince William
Spiranthes lacera (Raf.) Raf. var. *gracilis* (Bigelow) Luer	1	
Spiranthes vernalis Engelm. & Gray	1	
OSMUNDACEAE		
Osmunda cinnamomea L.	3	
Osmunda regalis L var. *spectabilis* (Willd.)	3	
OXALIDACEAE		
Oxalis sp.	2	
PINACEAE		
Pinus echinata P. Mill.	2	
Pinus rigida P. Mill.	2	
Pinus taeda L.	2	V, Fauquier
Pinus virginiana P. Mill.	1, 2	
PLANTAGINACEAE		
Plantago aristata Michx.	5	
POACEAE		
Agrostis hyemalis (Walt.) B.S.P.	1	V
Agrostis perennans (Walt.) Tuckerman	2	
Andropogon glomeratus (Walt.) B.S.P.	3	V, Prince William
Andropogon gyrans Ashe	1, 2	
Andropogon virginicus L.	1	
Aristida dichotoma Michx.	1, 5	
Aristida oligantha Michx.	1, 5	
Aristida purpurascens Poir.	1	V, Fauquier
Calamagrostis coarctata (Torr.) Eat.	3	V, Fauquier
Chasmanthium laxum (L.) Yates	2, 3	V, Prince William
Cynodon dactylon (L.) Pers. +	5	
Danthonia spicata (L.) Beauv. *ex* Roemer & J.A. Schultes	1, 2	

Scientific Name	**Habitat**	**County Record**
Dichanthelium acuminatum (Sw.) Gould & C.A. Clark	1, 2	
Dichanthelium clandestinum (L.) Gould	3, 4	
Dichanthelium commutatum (J.A. Schultes) Gould	2	
Dichanthelium depauperatum (Muhl.) Gould	1	
Dichanthelium dichotomum (L.) Gould Includes *Panicum dichotomum* L. var. *dichotomum*, *Panicum lucidum* Ashe, and *Panicum microcarpon* Muhl. ex Ell.	1, 2, 3, 4	
Dichanthelium scoparium (Lam.) Gould	3, 4	
Eragrostis spectabilis (Pursh) Steud.	1	
Festuca subverticillata (Pers.) Alexeev	2	
Leersia oryzoides (L.) Sw.	4	
Panicum anceps Michx.	1	
Panicum dichotomiflorum Michx.	5	
Panicum philadelphicum Bernh. *ex* Trin.	1	
Panicum rigidulum Bosc ex Nees var. *elongatum* (Pursh) Lelong	4	
Panicum rigidulum Bosc *ex* Nees var. *rigidulum*	3	
Panicum verrucosum Muhl.	3	V
Panicum virgatum L.	3	V
Paspalum laeve Michx.	1, 5	V
Paspalum setaceum Michx.	1	
Poa compressa L. +	1	
Poa pratensis L. +	1, 3	
Saccharum giganteum (Walt.) Pers.	3	V, Fauquier; V, Prince William
Schizachyrium scoparium (Michx.) Nash	1, 2	V
Setaria pumila (Poir.) Roemer & Schultes + = *Setaria glauca* (L.) Beauv.	1	
Setaria viridis (L.) Beauv. +	5	
Sorghastrum nutans (L.) Nash	1, 2, 3	
Sphenopholis obtusata (Michx.) Scribn.	1	V
Tridens flavus (L.) A.S. Hitchc.	1	
Vulpia octoflora (Walt.) Rydb.	1	
POLEMONIACEAE		
Phlox maculata L.	3	V, Prince William
POLYGALACEAE		
Polygala ambigua Nutt.	1	V
Polygala incarnata L.	1	
Polygala mariana P. Mill.	2, 3	V, Fauquier; V, Prince William
Polygala sanguinea L.	1, 3	
POLYGONACEAE		
Polygonum arifolium L.	4	
Polygonum persicaria L. +	3, 4	
Polygonum punctatum Ell.	4	
Polygonum sagittatum L.	3, 4	
Polygonum virginianum L.	2	
Rumex acetosella L. +	1, 5	

Scientific Name	**Habitat**	**County Record**
PORTULACACEAE		
Claytonia virginica L.	3	
POTAMOGETONACEAE		
Potamogeton diversifolius Raf.	4	
PRIMULACEAE		
Lysimachia quadrifolia L.	1, 2, 3	
RANUNCULACEAE		
Clematis virginiana L.	3	
Thalictrum pubescens Pursh	3, 4	
Thalictrum revolutum DC.	3	V
RHAMNACEAE		
Ceanothus americanus L.	2	
ROSACEAE		
Agrimonia parviflora Ait.	4	
Amelanchier canadensis (L.) Medik.	3	V
Amelanchier laevis Wieg.	2	
Amelanchier cf. *stolonifera* Wieg.	2	
Fragaria virginiana Duchesne	1	
Photinia pyrifolia (Lam.) Robertson & Phipps = *Aronia arbutifolia* (L.) Pers.	3	
Potentilla canadensis L.	1	
Potentilla simplex Michx.	2, 3	
Prunus serotina Ehrh.	2	
Rosa carolina L.	1, 2	
Rosa palustris Marsh.	3, 4	
Rubus flagellaris Willd.	1, 2, 3	
Rubus hispidus L.	2, 3	
Spiraea prunifolia Sieb. & Zucc. +	5	V, Fauquier
RUBIACEAE		
Cephalanthus occidentalis L.	4	
Diodia teres Walt.	5	
Galium circaezans Michx.	2	
Galium obtusum Bigelow	4	
Galium tinctorium (L.) Scop.	3, 4	
Galium triflorum Michx.	2	
Houstonia caerulea L.	1	
Houstonia purpurea L.	1, 2	
Mitchella repens L.	2	
SALICACEAE		
Populus grandidentata Michx.	1, 2, 3, 5	
Salix humilis Marsh.	2	V
Salix nigra Marsh.	4	
SANTALACEAE		
Comandra umbellata (L.) Nutt.	2	V; Stafford

Scientific Name	**Habitat**	**County Record**
SAURURACEAE		
Saururus cernuus L.	4	V, Fauquier
SCROPHULARIACEAE		
Agalinis purpurea (L.) Pennell	1, 3	
Agalinis tenuifolia (Vahl) Raf.	1, 3	
Gratiola neglecta Torr.	4	V, Stafford
Mimulus alatus Ait.	4	
Penstemon laevigatus Ait.	1	
SMILACACEAE		
Smilax glauca Walt.	2, 3	
Smilax rotundifolia L.	2	
SOLANACEAE		
Solanum carolinense L. +	5	
SPARGANIACEAE		
Sparganium americanum Nutt.	4	
THELYPTERIDACEAE		
Thelypteris noveboracensis (L.) Nieuwl.	3, 4	
Thelypteris palustris Schott var. *pubescens* (Lawson) Fern.	3, 4	
TYPHACEAE		
Typha latifolia L.	4	
URTICACEAE		
Boehmeria cylindrica (L.) Sw.	4	
VERBENACEAE		
Verbena hastata L.	4	
VIOLACEAE		
Viola cucullata Ait.	3, 4	
Viola x *primulifolia* L.	3	
Viola sagittata Ait.	1, 2	
Viola cf. *sororia* Willd.	2	
VITACEAE		
Parthenocissus quinquefolia (L.) Planch.	2	
Vitis labrusca L.	3	
XYRIDACEAE		
Xyris torta Sm.	3	V, Fauquier

Banisteria, Number 17, 2001
© 2001 by the Virginia Natural History Society

A Status Survey of Freshwater Mussel Populations in the Upper Clinch River, Tazewell County, Virginia

Jess W. Jones, Richard J. Neves, Matthew A. Patterson,
Chris R. Good, and Antoinette DiVittorio

Virginia Cooperative Fish and Wildlife Research Unit[1]
Department of Fisheries and Wildlife Sciences
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061

INTRODUCTION

Previous freshwater mussel surveys (1912-1997) at sites in the upper Clinch River in Tazewell County, Virginia, documented at least 27 species (Table 1). Presently, the mussel fauna in the upper Clinch River has been reduced to about 18 species, due principally to human impacts in the watershed and river. Degradation continues to jeopardize the mussel fauna and significantly impedes species recovery. For example, an estimated 5,300 liters (1,400 gallons) of a rubber accelerator (Octocure 554) spilled into the river from an overturned tanker truck on U.S. Route 460 in August 1998, just above Cedar Bluff near Clinch River Mile (CRM) 323.0. The toxic spill killed over 7,000 mussels of 16 species, including 182 endangered tan riffleshells, *Epioblasma florentina walkeri*, 51 endangered purple beans, *Villosa purpurpurea*, and 20 endangered rough rabbitsfoot *Quadrula cylindrica strigillata* (L.M. Koch, USFWS, pers. comm.). The majority of mussels were killed in a 5-6 mile (8-9 km) reach of river from Cedar Bluff downstream to Richlands. Previous mussel collections were made in this reach of river near Cedar Bluff and downstream (Table 1), with little survey effort focused on the upstream reach of river. This study was initiated in the summer of 1999 to determine the present status of mussel populations in the headwaters of the Clinch River above the town of Cedar Bluff upstream to Tazewell, Tazewell County.

MATERIALS AND METHODS

Study Area

During the summer of 1999, approximately 43 km (27 miles) of the upper Clinch River, [CRM 324.0-350.5 (CRK 521.4-564.1)], in Tazewell County, Virginia were surveyed for freshwater mussels (Fig. 1). This section of river drains two physiographic provinces, the Cumberland Plateau to the northwest and the Valley and Ridge to the southeast. The stream bottom is underlain primarily with limestone and shale, and historically was well suited for freshwater mussels. The river is fourth order in size throughout Tazewell County and features moderate to high gradient riffle-run fluvial morphology. The majority of our survey sites were located in the mainstem of the Clinch River, from above Cedar Bluff upstream to Tazewell. We also surveyed sites in second-order tributary streams. Topographic maps with locations of collection sites are on file at the Virginia Cooperative Fish and Wildlife Research Unit, Blacksburg, Virginia.

Qualitative Sampling

Freshwater mussels were sampled at 49 sites (Fig. 1, Tables 2 and 3), which were selected using 7.5 minute U.S. Geological Survey (USGS) topographic maps. Sampling sites were chosen based on accessibility

---

[1] The Unit is supported jointly by the U.S. Geological Survey, the Virginia Department of Game and Inland Fisheries, Virginia Polytechnic Institute and State University, and the Wildlife Management Institute.

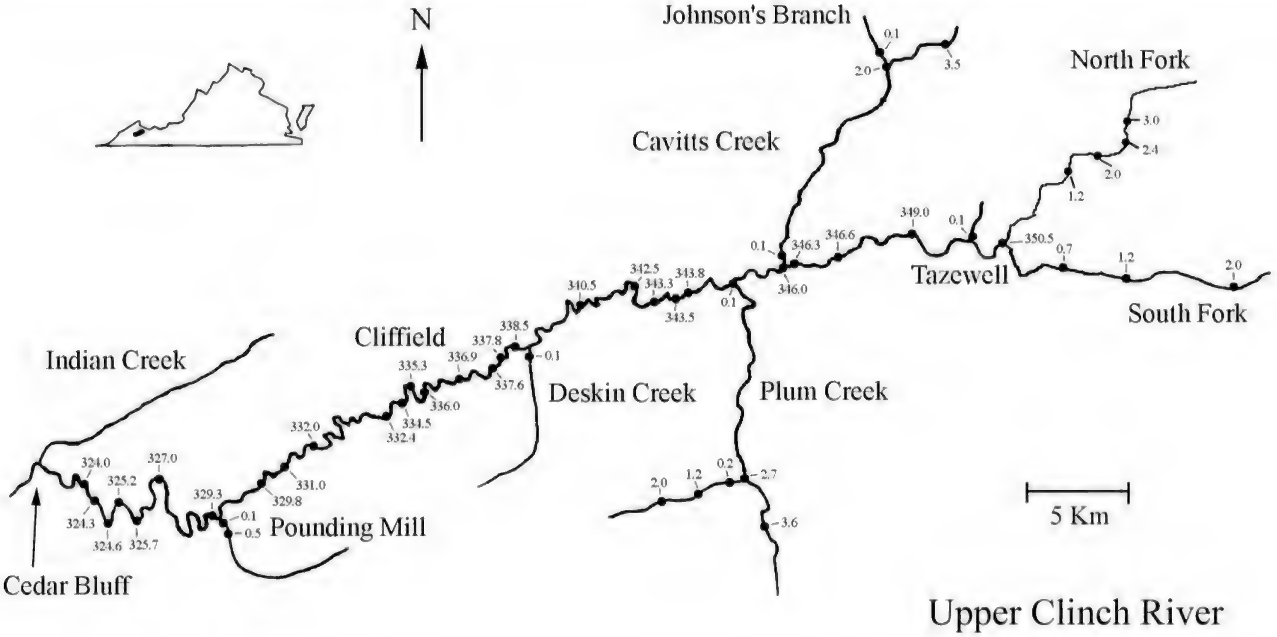


Fig. 1. Sites surveyed in 1999 for freshwater mussels in the upper Clinch River, Tazewell County, Virginia. Sites are reported as river or creek miles.

from roads or bridges, remoteness, and habitat types (e.g., mainstem sites vs tributary sites). The majority of our sampling effort was focused in riffles and runs that contained suitable substrates for freshwater mussels. Sites were surveyed by snorkeling, with 2-4 individuals searching side-by-side and moving upstream. A few sites in tributaries were too shallow for snorkeling; at these sites we walked in an upstream direction looking for live mussels protruding from the stream bottom. All fresh dead or relic shell material was also collected. Mussels were identified to species, counted, and immediately returned into the substrate at their collection site. Scientific names of mussels follow those of Turgeon et al. (1998), and the conservation status of each species follows that of Williams et al. (1992).

Estimates of substrate composition were assessed visually, based on the judgement of individual surveyors. At each site, the distance snorkeled was measured with a range finder (Bushnell, yardage pro 400) or visually estimated. Latitude and longitude were obtained with a March-II-E GPS unit (Corvallis Micro-Technology, Inc.). In addition to data reported in this paper, mussel abundance, qualitative observations on stream habitat, comments on the surrounding land use, and the latitude and longitude of all sites are reported in Jones et al. (1999).

RESULTS

Approximately 254 survey hours were spent sampling the upper Clinch River between Cedar Bluff and Tazewell. At each site, a mean of 5.2 person-hours was spent snorkeling, covering a mean distance of nearly 360 m. We recorded eight species of live freshwater mussels, totaling 4,115 individuals at the 28 sites sampled in the river (Table 2) and 21 sites sampled in tributaries (Table 3). These species, in order of relative abundance, were as follows (Table 4): rainbow mussel, *Villosa iris*, (71.76%), Cumberland moccasinshell, *Medionidus conradicus*, (12.68%), Tennessee heelsplitter, *Lasmigona holstonia*, (4.81%), Tennessee clubshell, *Pleurobema oviforme*, (4.73%), Tennessee pigtoe, *Fusconaia barnesiana*, (3.59%), wavyrayed lampmussel, *Lampsilis fasciola*, (2.35%), littlewing pearlymussel, *Pegias fabula*, (0.02%), and kidneyshell, *Ptychobranchus fasciolaris*, (0.02%). Seven additional species were represented only by the collection of relic shells; these species were the mucket

Table 1. Mussel species collected in the upper Clinch River, Tazewell County, Virginia. Collection records by Ortmann (1918), Stansbery et al. (1986), Ahlstedt (1991), Ahlstedt & Tuberville (1997), Winston & Neves (1997), Watson (1999), include sites at Cedar Bluff near CRM 322.5, but with few to no sites upstream. The present study (1999) is from CRM 324.0 just above Cedar Bluff, upstream to Tazewell at CRM 350.5.

	Publication Date						
Species	1918^1	1986^2	1991^3	1997^4	1997^5	1999^6	1999 (Present)
Actinonaias ligamentina							relic shells
Actinonaias pectorosa		X			X	X	relic shells
Alasmidonta marginata	X						
Alasmidonta viridis	X	X					relic shells
Elliptio dilatata	X						
*Epioblasma capsaeformis**	X						
*Epioblasma f. walkeri**		X		X	X	X	
Epioblasma haysiana	X						
Fusconaia barnesiana	X	X		X	X	X	X
*Fusconaia cor**					X		
*Fusconaia cuneolus**			X				
Fusconaia subrotunda	X	X				X	relic shells
Lampsilis fasciola	X	X		X	X	X	X
Lampsilis ovata	X			X	X	X	
Lasmigona costata	X	X			X	X	relic shells
Lasmigona holstonia	X	X			X		X
Lexingtonia dolabelloides	X	X			X		
Medionidus conradicus	X	X		X	X	X	X
*Pegias fabula**		X					X
Pleurobema oviforme	X	X			X	X	X
Ptychobranchus fasciolaris		X			X	X	X
Ptychobranchus subtentum	X	X			X	X	relic shells
*Quadrula c. strigillata**	X	X			X	X	
Strophitus undulatus	X						
Villosa iris	X	X	X	X	X	X	X
*Villosa perpurpurea**	X	X		X	X	X	
Villosa v. vanuxemensis					X	X	relic shells
Total number of species (27)	19	17	2	7	17	15	8

Actinonaias ligamentina, pheasantshell, *Actinonaias pectorosa*, slippershell mussel, *Alasmidonta viridis*, longsolid, *Fusconaia subrotunda*, flutedshell, *Lasmigona costata*, fluted kidneyshell, *Ptychobranchus subtentum*, and mountain creekshell, *Villosa v. vanuxemensis*.

The only federally endangered mussel found during the survey was one male littlewing pearlymussel, *Pegias fabula*, (length 40 mm, height 29 mm). This mussel was found at CRM 332.0, in a section of river between Cliffield and Pounding Mill. The riffle where the mussel was found was clean cobble, pebble, and sand free of silt; however, this reach of the river generally appeared moderately to heavily silted. At the Route 637 bridge crossing near Pounding Mill (CRM 329.8), a relic shell of this species also was found about 50 m downstream of the bridge. The habitat above and below the bridge is considered excellent for mussels, and other individuals of this species may inhabit this reach of river.

The state endangered *Lasmigona holstonia* was collected at 10 sites in five small tributary streams, and two sites in the mainstem Clinch River. However, each of the mainstem sites was immediately downstream of a tributary. The tributaries where this species occurs include the following streams: North Fork Clinch River, South Fork Clinch River, Cavitts Creek, Plum Creek, and West Fork Plum Creek (Table 3). Both the North Fork and South Fork contain healthy reproducing populations of *L. holstonia*. The greatest concentration was found in the South Fork Clinch River at River Mile 0.7 (Table 3), but this stream reach also was heavily sedimented with 30-50 mm of fine silt. Cattle have direct access to the stream, and the banks are severely degraded. This mussel species is restricted to small tributary streams, and it seems to be relatively tolerant of silt.

DISCUSSION

We recorded live specimens of eight mussel species in the present study, with only six of these species present in readily detectable numbers. Relic shells representing seven additional mussel species also were collected in this survey. In addition, the shell of a female tan riffleshell, *Epioblasma florentina walkeri*, a federally endangered species, was collected near Cliffield in 1985 (R.J. Neves, unpub. data). Therefore, if we assume that the 43 km section of the river between Cedar Bluff and Tazewell contained at least 16 species from historic records, then at least half of the fauna has been functionally extirpated. However, historic collection records (Table 1) indicate that at least 27 mussel species inhabited the Clinch River in Tazewell County, indicating an even greater faunal loss. The causes of this faunal decline are unknown, but anthropogenic impacts to the river were evident during our surveys. Moreover, based on the almost complete absence of relic shells of the original mussel fauna, many species likely were extirpated more than 20 years ago. The extant mussel species are considered tolerant of current watershed conditions and presumably withstood past perturbations to the river.

Although documentation of the causes for extirpation is lacking, inadequate or faulty treatment of sewage from Tazewell may be a contributing factor. Goudreau (1988) reported finding no live mussels in the Clinch River for 3.75 km (2.3 miles) below the sewage treatment plant located in South Tazewell. We also surveyed several sites in this reach of the river and found few live mussels. However, sewage effluent from the small treatment facility at Tazewell does not explain the low mussel diversity throughout the surveyed reaches of the upper Clinch River. Other impacts such as sedimentation, wastewater discharges from

Table 1. Continued.

*Federally endangered

X=live specimens in 1991-1999 surveys, and shells in 1918-1986 surveys.

[1] Sites were surveyed at Cedar Bluff (exact locations are unknown) in 1912 and 1913.

[2] Site at Cedar Bluff (CRM 322.7) was surveyed in 1981.

[3] Site at Cedar Bluff (CRM 322.7) was surveyed in 1979.

[4] Sites were surveyed at Cedar Bluff (CRM 322.7-322.8) in 1988 and 1994.

[5] Sites at Cedar Bluff (CRM 322.7) and Indian Creek were surveyed in 1995 and 1996.

[6] Indian Creek was surveyed in the summers of 1996 and 1997.

Table 2. Number of live mussel species found at 28 sampling sites in the upper Clinch River, Tazewell County, Virginia.

	River Miles													
Species	324.0	324.3	324.6	325.2	325.7	327.0	329.0	329.8	331.0	332.0	332.4	334.5	335.3	336.0
Villosa iris	180	150	210	100	400	220	15	173	32	34	115	50	35	35
Medionidus conradicus	80	15	32	20	50	45	---	36	15	22	89	15	15	18
Lasmigona holstonia	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Pleurobema oviforme	1	3	4	2	8	---	---	15	1	---	---	1	15	32
Fusconaia barnesiana	1	5	1	3	1	2	---	---	3	---	7	4	5	17
Lampsilis fasciola	10	---	5	3	10	1	---	13	3	5	26	3	2	2
Pegias fabula	---	---	---	---	---	---	---	---	---	1	---	---	---	---
Ptychobranchus fasciolaris	1	---	---	---	---	---	---	---	---	---	---	---	---	---
Total/site	273	173	254	128	469	268	15	237	54	62	237	73	72	104
Mussels/hour of effort	20.2	38.4	25.4	10.7	46.9	16.7	2.3	19.7	10.8	12.4	31.6	8.1	14.4	8.6

Table 2. Continued.

	River Miles													
Species	336.9	337.6	337.8	338.5	340.5	342.5	343.3	343.5	343.8	346.0	346.3	346.6	349.0	350.5
Villosa iris	69	74	32	25	40	2	---	---	---	45	39	17	5	147
Medionidus conradicus	9	24	10	10	2	---	---	---	---	1	---	---	---	---
Lasmigona holstonia	---	---	---	---	---	---	---	---	---	1	---	---	---	5
Pleurobema oviforme	21	16	16	10	4	19	---	---	---	3	---	---	---	---
Fusconaia barnesiana	---	---	1	2	39	2	---	3	1	13	10	6	---	---
Lampsilis fasciola	---	7	5	2	---	10	---	---	---	---	---	---	---	---
Pegias fabula	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Ptychobranchus fasciolaris	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Total/site	99	121	64	49	85	23	0	3	1	63	49	23	5	152
Mussels/hour of effort	16.5	20.2	10.7	12.3	8.1	7.6	0	1.0	0.1	8.4	14.0	7.0	2.5	38.0

Table 3. Number and species of live mussels at 21 sampling sites in tributary streams of the upper Clinch River, Tazewell County, Virginia, from June through August 1999.

	Creek Miles									
	Pounding Mill Branch		Deskin Creek	Plum Creek			West Fork Plum Creek			Johnson Branch
Species	0.1	0.5	0.1	0.1	2.7	3.6	0.2	1.2	2.0	0.1
Villosa iris	---	---	1	30	---	---	---	1	---	---
Medionidus conradicus	---	---	---	---	---	---	---	---	---	---
Lasmigona holstonia	---	---	---	---	1	---	15	19	---	---
Pleurobema oviforme	---	---	---	40	---	---	---	---	---	---
Fusconaia barnesiana	---	---	---	15	---	---	---	---	---	---
Lampsilis fasciola	---	---	---	---	---	---	---	---	---	---
Pegias fabula	---	---	---	---	---	---	---	---	---	---
Ptychobranchus fasciolaris	---	---	---	---	---	---	---	---	---	---
Total/site	0	0	1	85	1	0	15	20	0	0
Mussels/hour of effort	0	0	1.0	11.3	0.7	0	15.0	20.0	0	0

Table 3. Continued.

	Creek Miles										
	Cavitts Creek			Linconshire Branch	North Fork Clinch				South Fork Clinch		
Species	0.1	2.0	3.5	0.1	1.2	2.0	2.4	3.0	0.7	1.2	2.0
Villosa iris	10	18	50	1	122	236	1	---	170	---	---
Medionidus conradicus	---	6	1	---	---	---	---	---	---	---	---
Lasmigona holstonia	---	1	10	---	38	22	2	---	70	3	---
Pleurobema oviforme	---	---	---	---	---	---	---	---	---	---	---
Fusconaia barnesiana	---	2	1	---	---	1	---	---	1	---	---
Lampsilis fasciola	---	---	---	---	---	---	---	---	---	---	---
Pegias fabula	---	---	---	---	---	---	---	---	---	---	---
Ptychobranchus fasciolaris	---	---	---	---	---	---	---	---	---	---	---
Total/site	10	27	62	1	160	259	3	0	241	3	0
Mussels/hour of effort	3.3	13.5	16.5	1.0	15.2	43.2	1.0	0	48.2	1.0	0

Table 4. Summary of 1999 mussel collections in the upper Clinch River, Tazewell County, Virginia.

Species	Number collected	Percentage of collection	Sites of occurrence
Villosa iris	2,953	71.76	37
Medionidus conradicus	522	12.68	23
Lasmigona holstonia	198	4.81	14
Pleurobema oviforme	195	4.73	17
Fusconaia barnesiana	148	3.59	26
Lampsilis fasciola	97	2.35	15
Pegias fabula	1	0.02	1
Ptychobranchus fasciolaris	1	0.02	1
Total	4,115	100	49

residences along the river, and contaminant spills may have contributed to the decline. This section of the river has a very limited number of healthy mussel aggregations to allow mussels to recolonize impacted reaches of the river.

The small, mostly second-order tributary streams of the upper Clinch River have naturally low mussel diversity and would offer only 3-4 species to recolonize the mainstem Clinch. The only nearby tributary stream with a mussel assemblage similar to the Clinch is Indian Creek at Cedar Bluff. Watson (1999) reported 15 extant mussel species in this tributary (Table 1); however, mussel recolonization of the Clinch River above Cedar Bluff is impeded by an old mill dam located approximately 75 m upstream from the mouth of Indian Creek. A comparison between the mussel assemblages downstream and upstream of the mill dam demonstrates the effect this barrier has on recolonization. In a recent survey for rare mussels above and below the Business Route 460 bridge, which is just upstream of the mill dam, Beaty & Neves (1998) reported four species of live mussels from this reach of the river. Below the mill dam, 16 species were recorded in 1999, from the mouth of Indian Creek downstream to Richlands (L. M. Koch, USFWS, pers. comm.).

Mussel abundance and diversity is now low in the Clinch River headwaters, from its source at Tazewell downstream to about Cliffield. This approximately 24 km (15 mile) stretch of river is moderately to heavily silted, and appears to have been affected by wastewater effluent and habitat degradation from Tazewell. Excessive sediment inputs from tributaries degraded by livestock, such as the South Fork Clinch River and Plum Creek, also may be contributing to mussel declines. Evidence of recent mussel recovery in this reach is lacking, and recruitment is probably occurring only at very low levels. Furthermore, there are few stream reaches in the upper river suitable for the reintroduction of laboratory-propagated juvenile mussels. One suitable location is the North Fork Clinch River above Tazewell (River Mile 1.2). This reach contained healthy populations of *Lasmigona holstonia* and *Villosa iris*, with young individuals of both species present. If necessary, population augmentation of *L. holstonia* may be feasible at this location. Mussel abundance and diversity begins to increase somewhere between Cliffield and Pounding Mill. This approximately 11 km (7 mile) section of river is moderately silted, but contains good habitat for mussels. There is evidence of limited mussel reproduction, with a few young individuals less than 20 mm collected in this reach during the survey. However, we consider this section of the river only marginally suitable for reintroduction of propagated juvenile mussels. The surrounding land use consists of pasture and small homes along the river banks; therefore, many riparian areas are not well protected. Mussel abundance improves significantly from Pounding Mill to above Cedar Bluff, with species diversity being about the same as the aforementioned section of river. This approximately 8 km (5 mile) section of the river appears clean, relatively free of silt, and is well protected by surrounding forest. Mussels are common, with young individuals present at all sites surveyed. From CRM 324.0 to 327.0, the river conditions appear excellent for the reintroduction of propagated juvenile mussels. This reach of river contains suitable flow and several gravel shoals more than 100 m in length that appear adequate for reintroduction of species such as the endangered *Epioblasma florentina walkeri* and *Villosa perpurpurea*.

The occurrence of viable populations of federally endangered mussel species in the surveyed section of the upper Clinch River is unlikely. With the collection of only one live *Pegias fabula*, even the continued existence of this endangered species in the river is tenuous. A status survey covering the known range of this Cumberlandian species by Ahlstedt & Saylor (1995-1996) found only one small population in Virginia, in the upper North Fork Holston River. These authors noted that the species is extremely rare in the Virginia portion of its range. In the upper Clinch River, collection records indicate that *P. fabula* has been recorded only a few times: Cedar Bluff (1978; n=2) and Cliffield (1968; n=1) (Stansbery et al., 1986), and Cliffield (1985; n=1) (R. J. Neves, unpub. data). The state endangered *L. holstonia* is the only rare species collected during the survey in viable numbers; it is moderately abundant and reproducing in several of the small tributary streams of the upper Clinch River. These populations appear stable at this time.

The spill of toxic rubber accelerator at Cedar Bluff in August of 1998, immediately downstream of our study area, effectively extended the depauperate mussel fauna of the upper river another 8-9 km (5-6 miles) downstream. The accident killed at least 7,036 mussels of 16 species (L.M. Koch, USFWS, pers. comm.), to include eradicating the only population of endangered *E. f. walkeri*, and nine other mussel species in the mainstem Clinch River in Tazewell County (Table 5). Assuming that river conditions are now suitable for faunal recovery, we estimate that it will take decades for these mussel species to naturally recolonize the affected river reach, or require reintroductions over many years to achieve population levels comparable to those prior to the spill.

Compared to the original fauna of 16-27 mussel species, the upper Clinch River between Cedar Bluff and Tazewell, Virginia, has been severely depleted of both species richness and abundance. The reach from Tazewell to Cliffield appears degraded, with little or no evidence that the mussel fauna is improving in this part of the river. In contrast, the mussels in the reach from Pounding Mill to 0.5 km above Cedar Bluff seem to be reproducing. Several common species such as *M. conradicus*, *V. iris*, *L. fasciola*, *F. barnesiana*, and *P. oviforme* are common and reproducing in this 9 km reach of the river. Noticeably absent from the surveyed section of the river are many other common species for the Clinch River, such as *Lampsilis ovata*, *Ptychobranchus fasciolaris*, *P. subtentum*, *Lasmigona costata*, and *Villosa v. vanuxemensis*. Populations of these species are readily available in the lower river and could either be translocated or propagated for release to sites in need of restoration. If reintroduction efforts such as these are successful, then the establishment of self-sustaining populations of endangered tan riffleshell, purple bean, and other species in the river above Cedar Bluff could restore much of the fauna lost in the 20th century.

Table 5. Mussels killed by the 27 August, 1998 chemical tanker spill in the Clinch River at Cedar Bluff, Virginia. Mussels salvaged in the kill zone were from CRM 322.5 downstream to approximately CRM 317.0 at Richlands.

Species	Number salvaged
Villosa iris	3,602
Lampsilis fasciola	1,083
Ptychobranchus fasciolaris	721
Fusconaia barnesiana	604
Medionidus conradicus	190
*Epioblasma florentina walkeri**	182
Pleurobema oviforme	165
Actinonaias pectorosa	144
Lasmigona costata	106
Lampsilis ovata	73
Ptychobranchus subtentum	66
*Villosa perpurpurea**	52
Villosa v. vanuxemensis	26
*Quadrula cylindrica strigillata**	20
Elliptio dilatata	1
Strophitus undulatus	1
Total (16 species)	7,036

*Federally endangered

ACKNOWLEDGMENTS

The survey was funded by the U.S. Fish and Wildlife Service, Abingdon, Virginia. We would like to thank Leroy Koch and Kathleen Gilbert for assisting with fieldwork, and the many landowners in Tazewell County who granted us permission to access the river through their properties.

LITERATURE CITED

Ahlstedt, S. A. 1991. Twentieth century changes in the freshwater mussel fauna of the Clinch River (Tennessee and Virginia). Walkerana 5: 73-122.

Ahlstedt, S. A., & C. F. Saylor. 1995-1996. Status survey of the little-wing pearlymussel, *Pegias fabula* (Lea 1838). Walkerana 8: 81-105.

Ahlstedt, S. A., & J. Tuberville. 1997. Quantitative reassessment of the freshwater mussel fauna in the Clinch and Powell Rivers, Tennessee and Virginia. A national strategy for the conservation of native freshwater mussels. Pp. 72-97 *in* K. S. Cummings, A. C. Buchanan, C. A. Mayer, & T. J. Naimo, eds. Conservation and management of freshwater mussels II: Initiatives for the future. Proceedings of a UMRCC symposium, 16-18 October 1995, St. Louis, Missouri, Upper Mississippi River Conservation Committee, Rock Island, IL.

Beaty, B., & R. J. Neves. 1998. Survey of the freshwater mussel fauna at the Business Route U.S. 460 bridge, Tazewell County, Virginia. Final Report to the Virginia Department of Transportation, Richmond, VA. 4 pp.

Goudreau, S. E. 1988. Effects of sewage treatment plant effluents on mollusks and fish of the Clinch River in Tazewell County, Virginia. Master's Thesis, Department of Fisheries and Wildlife, Virginia Polytechnic Institute and State University, Blacksburg, VA. 128 pp.

Jones, J. W., R. J. Neves, M. A. Patterson, C. R. Good, & A. DiVittorio. 1999. A survey to evaluate the status of freshwater mussel populations in the upper Clinch River, Tazewell County, Virginia. Final Report to the U.S. Fish and Wildlife Service, Abingdon, VA. 40 pp.

Ortmann, A. E. 1918. The nayades (freshwater mussels) of the upper Tennessee drainage, with notes on synonymy and distribution. Proceedings of the American Philosophical Society 57: 521-626.

Stansbery, D. H., C. B. Stein, & G. T. Watters. 1986. The distribution and relative abundance of unionid mollusks in the Clinch River in the vicinity of Appalachian Power Company's Clinch River Plant at Carbo, Virginia (Clinch River miles 264-270). The Ohio State University Research Foundation, Project 764801/717333. Columbus, OH. 184 pp.

Turgeon, D. D., J. F. Quinn, Jr., A. E. Bogan, E. V. Coan, F. G. Hochberg, W. G. Lyons, P. M. Mikkelsen, R. J. Neves, C. F. E. Roper, G. Rosenberg, B. Roth, A. Scheltema, F. G. Thompson, M. Vecchione, & J. Williams. 1998. Common and scientific names of aquatic invertebrates from the United States and Canada: mollusks. Second edition. American Fisheries Society, Special Publication 26, Bethesda, MD. 526 pp.

Watson, B. T. 1999. Population biology and fish hosts of several federally endangered freshwater mussels (Bivalvia: Unionidae) of the upper Tennessee River drainage, Virginia and Tennessee. Master's Thesis, Virginia Polytechnic Institute and State University, Blacksburg, VA. 134 pp.

Williams, J. M., M. L. Warren, Jr., K. S. Cummings, J. L. Harris, & R. J. Neves. 1992. Conservation status of freshwater mussels of the United States and Canada. Fisheries 18 (9): 6-22.

Winston, M. R., & R. J. Neves. 1997. Survey of the freshwater mussel fauna of unsurveyed streams of the Tennessee River drainage, Virginia. Banisteria 10: 3-8.

Banisteria, Number 17, 2001
© 2001 by the Virginia Natural History Society

Natural History of Amphibians, Reptiles, and Small Mammals in a Degraded Environment in Southeastern Virginia

Joseph C. Mitchell

Department of Biology
University of Richmond
Richmond, Virginia 23173

A. Scott Bellows

Department of Biological Sciences
Old Dominion University
Norfolk, Virginia 23529

C. Todd Georgel

Department of Biology
Christopher Newport University
Newport News, Virginia 23606

Joseph S. Ferris

AH Environmental Consultants
7406 Alban Station Court, Suite B-206A
Springfield, Virginia 22150

INTRODUCTION

It is well known that urbanization, industrialization, and other forms of land disturbance cause population declines and local extirpations of many animals and plants. Habitat loss and degradation are primary causes of decline in amphibian and reptile populations and species (Alford & Richards, 1999; Gibbons et al., 2000) and alteration and decline of some mammal populations. The amphibian, reptile, and small mammal faunas of altered landscapes have not been well studied in southeastern Virginia. Most recent studies of these vertebrates in this region have been conducted in protected jurisdictions, such as the Great Dismal Swamp National Wildlife Refuge (Breidling et al., 1983; Rose et al., 1990; Mitchell et al., 2000), Back Bay National Wildlife Refuge (Pague & Mitchell, 1991; Mitchell & Pague, 1991), and Seashore State Park (Buhlmann et al., 1994). The few more widespread studies revealed that terrestrial vertebrate communities exist in habitat fragments and have fewer numbers of species compared to the protected areas (Erdle & Pagels, 1995; Mitchell et al., 1998). Evaluation of areas that have been used heavily for agricultural, commercial, and military purposes provide information on one end of the pristine to degraded landscape spectrum.

We recently had the opportunity to evaluate a highly degraded site in southeastern Virginia that has been designated a U.S. Environmental Protection Agency Superfund Site. Our objectives in this study were to (1) inventory the major terrestrial and aquatic habitats on the site for amphibians, reptiles, and small mammals, (2) determine whether any state and federal endangered and threatened species occur there, and (3) determine which species may be targeted in later efforts for ecotoxicological evaluations.

MATERIALS AND METHODS

Study Site

The Former Nansemond Ordnance Depot (FNOD), located at the northeastern corner of Suffolk south of the James River (Fig. 1), was used by the U.S. Army and other branches of the United States military for deployment, storage, and refurbishing of explosives from World War I through the early 1960s when it was sold to state and private interests. Most of the area (394 ha) was cleared of natural vegetation and former agricultural lands, then developed with large open areas, storage buildings, and working areas, including landfills. Tidewater Community College Suffolk Branch, General Electric Company, Dominion Properties, Hampton Road Sanitation District, and the Virginia Department of Transportation currently operate facilities on the site. Interstate 664 fragments the FNOD site into eastern and western parcels. Areas not under current use have been allowed to proceed through vegetational succession; habitat types now occurring on the site are described below. The flora and fauna that occur in this area today represent populations that have grown from the small fragments that persisted throughout occupation or have colonized the area since its use by the military.

The type and extent of plant communities observed at the site were dictated largely by past human activity, topographic setting (in areas bordering the Nansemond and James rivers), and by tidal action and salinity. As noted previously, much of the site is in a developed state or has undergone significant alteration from past human activities associated with operations at the FNOD. Nine natural habitat types defined through field surveys and aerial photography occur at the site. These include the following, as well as a category for Developed Lands. We include the number of trap days (nights) for each trapping method used to quantify inventory effort. Sites are mapped in Fig. 1.

Upland Habitats

Early successional scrub/shrub and mixed woodland (ES) - Early successional scrub/shrub and mixed woodland typify areas of the site that received heavy and protracted disturbance from operations associated with the FNOD. Many of these areas supported buildings and were likely landscaped with grass and an occasional tree or clusters of trees. Today, these areas support a mosaic of open scrub/shrub communities, interspersed with relatively mature trees or clusters of trees. Characteristic species observed within this early successional community include black locust (*Robinia pseudoacacia*), tree-of-heaven (*Ailanthus altissima*), red cedar (*Juniperus virginianus*), mimosa (*Albizia julibrissin*), hackberry (*Celtis occidentalis*), multiflora rose (*Rosa multiflora*), privet (*Ligustrum* sp.), brambles (*Rubus* sp.), honeysuckle (*Lonicera japonica*) and English ivy (*Hedera helix*). Herbaceous components of this plant community included sericea (*Lespedeza cuneata*), cinquefoil (*Potentilla* sp.), yarrow (*Achillea millifolia*), orchard grass (*Dactylus glomerata*), fireweed (*Erechtites hieraciflolia*), wild carrot (*Daucus carota*), tall goldenrod (*Solidago altissima*), asters (*Aster* spp.), yellow wood sorrel (*Oxalis stricta*), chickweed (*Stellaria* spp.) and dog fennel (*Eupatorium capillifolium*). The scattered large trees were primarily loblolly pine (*Pinus taeda*), cherrybark oak (*Quercus falcata* var. *pagodifolia*), and sweetgum (*Liquidambar styraciflua*). Effort - 190 TN snap traps, 400 TN pitfalls. Sites 7, 9, 13, 14.

Evergreen (pine) dominated forest (PI) - Mature and medium-aged, evergreen dominated forests were observed on upland terraces of the FNOD. Although they have a mix of deciduous and evergreen species, these forests are characterized by a predominance of relatively even-aged loblolly pine in the overstory. Subcanopy trees include sweetgum, red cedar, black cherry (*Prunus serotina*), and American holly (*Ilex opaca*). Understory species include poison ivy (*Toxicodendron radicans*), honeysuckle, Virginia creeper (*Parthenocissus quinquefolia*), catbrier (*Smilax glauca*), yellow jasmine (*Gelsemium sempervirens*), sweet vernal grass (*Anthoxanthum odoratum*) and ebony spleenwort (*Asplenium platyneuron*). Effort - 170 TN snap traps, 400 TN pitfalls. Site 8.

Mixed hardwood and evergreen (pine) forest (HWP)– Mature and medium-aged, mixed forests were identified at the site primarily from side-slopes and ridges within the FNOD which had received the least disturbance from past human activity. These areas likely come closest to representing the original plant community composition present prior to development and operation of the FNOD. Characteristic tree species include cherrybark oak, loblolly pine, red maple (*Acer rubrum*), and sweetgum in the overstory, with southern red oak (*Quercus falcata*), sassafras (*Sassafras albidum*), black gum (*Nyssa sylvatica*), and flowering dogwood (*Cornus florida*) as understory trees. Predominant species of the shrub layer include horse sugar (*Symplocos tinctoria*), mountain laurel (*Kalmia latifolia*), red bay (*Persea borbonia*), wild muscadine (*Vitis rotundifolia*) , yellow jasmine, and Virginia

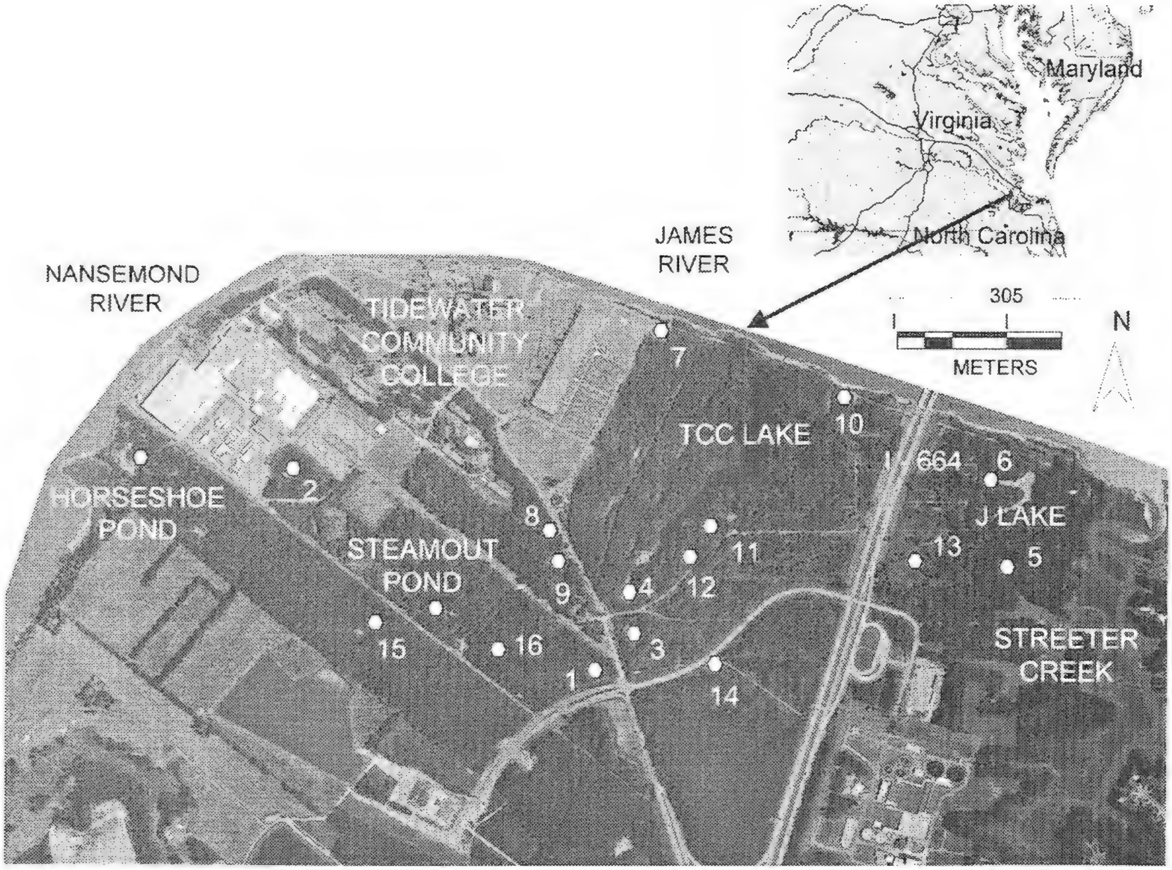


Fig. 1. Location of the FNOD study site in Suffolk, Virginia. Specific study sites are numbered or named.

creeper. Spotted wintergreen (*Chimaphila maculata*), Virginia grapefern (*Botrychium virginianum*), and Nepal microstegium (*Microstegium vimineum*) were noted species in the herbaceous layer. Effort – 517 TN snap traps, 400 TN pitfalls. Sites 5, 6, 10, 11, 12, 15, 16, Steamout Area.

Hardwood forest (HW) - The primary hardwood forest habitats on the FNOD site are along the TCC Lake and near the Horseshoe Pond. Characteristic tree species along the lake include cherrybark oak, red maple, southern red oak, and sweetgum in the overstory, with sassafras, black gum, loblolly pine, and flowering dogwood (*Cornus florida*) as understory trees. Hackberry and mulberry (*Morus* sp.) were the major tree species at the Horseshoe Pond with black walnut (*Juglans nigra*) and loblolly pine as minor components. Understory trees consisted of these four species. Vines were abundant and consisted of muscadine grape, slender woody vine (*Smilax rotundifolia*), honeysuckle, and trumpet creeper (*Campsis radicans*). The thick herbaceous cover was comprised of pokeweed (*Phytolacca americana*) and smartweed (*Polygonum pennsylvanicum*). Effort - 266 TN snap traps. Horseshoe Pond site.

Developed Lands (DEV) - This habitat type consisted mostly of occupied buildings, lawns, and parking lots associated with TCC, the commercial and state businesses on the site, and abandoned and now overgrown areas of the former depot. Effort - haphazard observations. Sites 7, 10, 11.

Wetland Habitats

Nontidal, palustrine forested, seasonally to semi-permanently saturated wetlands (FW) - Nontidal, palustrine forested wetlands were observed at scattered locations, generally associated with small, unnamed drainageways feeding one of the man-made ponds found within the FNOD. A relatively large area of palustrine forested wetlands occurs at the upper reaches of the primary drainageway feeding TCC Lake. Characteristic tree species included cherrybark oak, American elm (*Ulmus americana*), red maple, and bald cypress (*Taxodium distichum*) in the overstory, with sweet bay (*Magnolia virginica*), green ash (*Fraxinus pennsylvanica*), alder (*Alnus serrulata*), high-bush blueberry (*Vaccinium corymbosum*), and water loosestrife (*Decodon verticillatus*) as understory trees and shrubs. Predominant species noted in the herbaceous layer included jewelweed (*Impatiens capensis*), lizard tail (*Saururus cernuus*), false nettle (*Boehmeria cylindrica*), shallow sedge (*Carex lurida*), royal fern (*Osmunda regalis*), New York fern (*Thelypteris novaboracensis*) and chain fern (*Woodwardia aereolata*). Effort - 67 minnow trap days. Sites 1 and 7.

Nontidal, seasonally to permanently flooded, freshwater ponds (PO) - A number of freshwater ponds occur throughout the site. The majority of these appear to be man-made (either through excavation or impoundment), although several near the southwestern boundary of the study area may occur in natural depressions. The largest is TCC Lake, which by historical accounts, was a tidally influenced tributary of the James River prior to construction of a causeway at its mouth. In general, the ponds are not vegetated, except for floating aquatic duckweeds (*Spirodella oligorhiza* and *Lemna* sp.) and eastern mosquito fern (*Azolla caroliniana*). Many of the ponds were observed to support small areas of wetlands. Predominant species noted from these wetlands included willow (*Salix* sp.), buttonbush (*Cephalanthus occidentalis*), smartweeds (*Polygonum hydropiperoides*, *P. pensylvanicum* and *P. lapathifolium*), rice cutgrass (*Leersia oryzoides*), soft rush (*Juncus effusus*), Virginia button-weed (*Diodia virginiana*), and blunt spikerush (*Eleocharis obtusa*). Effort - 319 minnow trap days. Sites 2, 3, 4, 5, 6, Horseshoe, Steamout.

Intertidal, estuarine emergent wetlands (brackish marsh) (EW) - Tidal wetlands were observed along the shores of the Nansemond and James rivers and in association with Streeter Creek. Although scattered throughout the shoreline of the FNOD, tidal wetlands were best developed along Streeter Creek and on an accreting bar at the western corner of the study area. These wetlands are strongly controlled by the tides and ocean-derived salts. They are dominated by emergents with a scattering of shrub species. Plant species noted from these brackish marshes included groundsel tree (*Baccharis halmifolia*), marsh elder (*Iva frutescens*), big cordgrass (*Spartina cynosuroides*), smooth cordgrass (*Spartina alternifolia*), saltmeadow hay (*Spartina patens*), salt grass (*Distichlis spicata*), glasswort (*Salicornia* sp.), seashore mallow (*Kosteletzkya virginica*), seaside goldenrod (*Solidago sempervirens*), sea lavender (*Limonium carolinianum*), saltmarsh bulrush (*Scirpus robustus*), and sea oxeye (*Borrichia frutescens*). Effort - haphazard observations.

Ephemeral pools (EP) - Shallow depressions, such as woodland vernal pools and road ruts, often hold water long enough for amphibians to breed, pass through the larval period, and reach metamorphosis. There were two vernal pools in the section south of the Steamout Pond Area that contained a diversity of amphibians and reptiles. The larger of these pools contained small sweetgum trees. No duckweed or emergent vegetation was observed in the vernal pools. Effort - 8 minnow trap days. Site 15.

Open water (OW) - Open water pertains primarily to the James River adjacent to the FNOD site on its north side and the Nansemond River on its west. These river areas were not surveyed, however, the species expected would be similar to those occupying Streeter Creek, a tidally influenced tributary of the James River. Effort - haphazard observations. The only site for this habitat was the river adjacent to site 10.

METHODS

We inventoried the FNOD site for amphibians, reptiles, and small mammals on five 2-3 day field trips during the period of 3 May through 16 August 2000. Trip dates were 3-4 and 18-19 May, 8-9 and 28-29 June, and 14-16 August. The site was also visited on 3 April 2001.

We used multiple inventory techniques to survey for these taxa in different aquatic and terrestrial habitat types on FNOD. To capture terrestrial vertebrates we installed 40 pitfall traps (1 gallon, 3.8 L, plastic pails) in early successional, pine plantation, and mixed pine and hardwood habitats. Pitfalls were arranged in a 40 x 100 meter grid with traps set 10 m apart from each other. These traps contained 3-5 inches (7.5-12.5 cm) of water and were covered with a section of roofing shingle when not in use. They were opened the day before we arrived on site and left open for two nights. Total number of pitfall trap nights during the course of the study was 400 for each habitat type (total = 1600). We also set standard small mammal (museum special) snap traps baited with peanut butter and oatmeal in several sites each visit, including the three sites containing pitfall traps. These were set for one trap night each on all but the last site visit when they were set the day before we arrived (2 nights). Total number of snap trap nights was 1,252.

For aquatic vertebrates we set standard minnow traps in shallow portions of 11 wetland sites on FNOD. Each trap was set with the upper portion above water to avoid drowning air-breathing vertebrates such as frogs, snakes, and turtles. Each trap was checked and pulled the following day. Total number of trap days was 394. We also noted all species observed visually and frogs heard calling in and around each site during day and night visits to the wetlands. We recorded species observed with binoculars (turtles) and those we heard or saw while walking through various habitats and areas.

We surveyed for bats with mist nets on May 8 and August 15. Four mist nets (two=12x3 m, one=6x3 m, and one=9x3 m) were set near the upper end of the large Tidewater Community College pond on the first date and five (two=12x3 m, two=6x3 m, and one 3x6 m) were set in the western end of the Steamout Pond area on the edge of a field on the second date.

We recorded developmental stage of many tadpoles captured using the following stages, modified after Gosner (1960): tadpole with no limb buds to Gosner stage 25 (Stage I), limb buds present to Gosner stage 34 (Stage II), small rear legs present to Gosner stage 39 (Stage III), large rear legs to Gosner stage 41 (Stage IV), near metamorph with forelegs and most of tail present (Stage V), metamorph with short tail bud (Stage VI), and full metamorph without tail bud and with fully formed mouth (Stage VII). All measurements of snout-to-vent length were taken in mm with a plastic ruler. Turtles were measured with calipers. We obtained body masses with Pesola® scales. We also recorded abnormalities and injuries when present.

RESULTS

The number of species observed or captured on the FNOD site was a subset of those expected for the area based on distribution patterns and habitat availability. Of the 16 species of frogs expected for the site, eight were confirmed. No salamanders were found on the site despite the fact that as many as nine could have occurred there. Two of seven species of lizards were confirmed, as were four species of 19 possible snake species. We documented six of eleven species of turtles that were expected on the site or along the James River and its tributaries. We found no evidence of federally protected sea turtles in the area but they may occasionally become stranded on the beach along the James River. The diamond-backed terrapin (*Malaclemys terrapin*) is considered a Federal Species of Concern (U.S. Fish and Wildlife Service), although it has no legal protection. One shell was found on the beach at the beachfront landfill site. One subspecies of freshwater turtle, the red-eared slider (*Trachemys scripta elegans*), has been introduced into the region via the pet trade and is genetically swamping local populations of the yellow-bellied slider (*Trachemys scripta scripta*) in southeastern Virginia (Mitchell, 1994). However, no sliders were observed in any of the ponds.

Nineteen species of rodents and insectivores were expected for the area but only nine were confirmed. None is listed as endangered or threatened. One of the rodents was the introduced house mouse (*Mus musculus*). The white-footed mouse (*Peromyscus leucopus*) was the most abundant small mammal on the FNOD site. We captured one adult male and one female red bat (*Lasiurus borealis*) on May 8; no bats were captured in the Steamout Pond field, however, two bat calls were detected acoustically there using an ANABAT™ ultrasonic detector. The species were not determined.

Evaluation of the number of species by terrestrial habitat type (Table 1) reveals that the mixed hardwood and pine community supports the largest number of amphibian and reptile species on the FNOD site, whereas the early successional habitat supports the highest diversity of small mammals. The mixed forest is the most common vegetated habitat on the site and would be expected to support terrestrial stages of most frogs and nearly all of the terrestrial reptiles. Early successional habitats support the highest diversity of small mammals in the region due to the extensive grass cover and food supply for these grass and seed consumers.

Comparison of the amphibians and reptiles of the aquatic habitats on the FNOD site reveals that all these habitats support relatively high diversities of these animals (Table 1). This makes intuitive sense, as all the frogs breed in these habitats and most turtles inhabit them most of the time. These wetlands are obviously critical habitats for these vertebrates on the FNOD site. It should be noted, however, that all of the species that inhabit the wetlands also use terrestrial habitats extensively. This includes upland use during the non-breeding periods (frogs), dispersal from breeding sites (frogs, turtles), and egg laying in terrestrial sites by the aquatic turtles.

Annotated Species Accounts

Frogs

Bufo terrestris (2, 4, 7, 8, 12, 13, 14, 15, 16, Horseshoe, Steamout)

This species was encountered on each trip to the site.

Table 1. Relative abundance of amphibians, reptiles, and small mammals on the FNOD Superfund site, Suffolk, Virginia by habitat type. Habitat abbreviations: ES = early successional, PI = pine, HWP = mixed hardwoods and pine, HW = hardwoods, DEV = developed lands, FW = palustrine fresh water, PO = freshwater ponds, EW = estuarine emergent wetlands, EP = ephemeral pools, and OW = open water tidal. Abundance codes: U = uncommon (1-3 occurrences), C = common (4-9 occurrences), A = abundant (>9 occurrences).

Species	ES	PI	HWP	HW	DEV	FW	PO	EW	EP	OW
Frogs										
Bufo terrestris	U	U	U	U	C	A	C		A	
Gastrophryne carolinensis	U	U					C			
Hyla cinerea						A	A		A	
Pseudacris crucifer			C		U	C	A		A	
Rana catesbeiana		U	U	U		U	A		C	
Rana clamitans					U	U	A		C	
Rana sphenocephala	U	U	U		C	A	A		A	
Scaphiopus holbrookii		C								
Lizards										
Eumeces fasciatus		U	U							
Scincella lateralis			U							
Snakes										
Coluber constrictor			U							
Diadophis punctatus			U							
Nerodia sipedon					U	U	C			
Thamnophis sauritus							U			
Turtles										
Chrysemys picta						U	U		U	
Chelydra serpentina							C	U	U	U
Kinosternon subrubrum	U						U	U		
Malaclemys terrapin										U
Pseudemys rubriventris							C			
Terrapene carolina	U			C	U					
Small Mammals										
Blarina brevicauda	U	C		U						
Cryptotis parva	U									
Glaucomys volans			U							
Mus musculus	U									
Ochrotomys nuttalli	U									
Peromyscus leucopus	U		C	A	U					
Reithrodontomys humulis	U									
Sigmodon hispidus	U									

We found tadpoles on 4 and 18 May and 9 June (Table 2). The sample from site 7 collected on 4 May contained developmental stages II-V. Full metamorphs (stage VII, 9-13 mm SVL, 0.06-0.19 g, N = 39) were abundant around site 7 on 18 May. One was missing its left rear leg. The largest adult male measured 55 mm SVL and weighed 16 g and the largest adult female was 81 mm and 46 g. Four adults (1 female, 3 males) were found dead on 3 April 2001 at site 7. Each had been eviscerated by an unknown predator, who ate only the lower jaw, arms, and pectoral regions. The dorsum was avoided. Fresh egg masses were observed on this date at Site 7.

Gastrophryne carolinensis (2, 8, 13, Steamout)

Most of the individuals captured were found in pitfall traps in early successional and pine habitats. No males were heard calling. Tadpoles in stages III and IV were found in the Steamout Pond on 16 August. The largest female was 32 mm SVL and the largest male was 34 mm SVL.

Hyla cinerea (4, 7, 15, Horseshoe, Steamout)

Males were heard calling on 18 May and 8 June. Females with eggs were captured on 8 June. Adult males were 36-48 mm SVL and weighed 2.9-6.3 g (N = 29) and adult females were 39-50 mm SVL and weighed 3.8-7.6 g (N = 6). Tadpoles in modified Gosner stages III and IV were found on 29 June and 16 August in site 7. Tadpoles in stage I were found in the Steamout Pond on August 16.

Pseudacris crucifer crucifer (2, 3, 4, 7, 15, 16, Steamout)

A single tadpole was found in site 7 on 3 May. No males were heard calling in May but large choruses were heard in all of the noted wetlands on 3 April 2001.

Rana catesbeiana (1, 2, 3, 4, 6, 8, 12, 15, Horseshoe, Steamout)

Adults, juveniles, and tadpoles of this frog was observed commonly in several sites. Calls were heard on 3 May and 8 June. Tadpoles were found on all site visits. Series obtained from the J-pond on five occasions show changes in developmental stages over a 3.5 month period (Table 2). The sample from 16 August shows that tadpoles from a previous year's cohort (1998 or 1999) were proceeding through metamorphosis and that most tadpoles from the 2000 cohort had already developed limb buds. Tadpoles that were in stage V (metamorphs with tail present) were captured on 9 and 29 June and 16 August, indicating that metamorphosis of the putative 1998 or 1999 cohort largely occurred during July and August. The largest male measured 111 mm SVL and 119 g and the largest female was 142 mm SVL and 310 g.

Rana clamitans melanota (1, 2, 4, 6, 7, 15, Steamout)

This frog was heard calling on 18 May. Most observations were of juveniles. Only one adult was captured, a 68 mm SVL and 27 g male in the Steamout Pond.

Rana sphenocephala utricularia (2, 4, 6, 7, 8, 12, 13, 14, 15, Horseshoe, Steamout)

One male was heard calling on 8 June. Most

Table 2. Developmental chronology for tadpoles of three species of frogs at the FNOD site in Suffolk, Virginia. Stages I-VII are described in the text. N is sample size and numbers are percent of sample size. Site numbers refer to those in Fig. 1. H is the Horseshoe Pond site.

Species/ Date	Site	N	I	II	III	IV	V	VI	VII
Bufo terrestris									
4 May	7	37		18.9	81.8				
18 May	7	61		11.5	24.5			9.8	54.1
9 June	7	2			100.0				
Rana catesbeiana									
4 May	6	142		84.5	15.5				
19 May	6	64		67.2	29.7	3.1			
9 June	6	33		12.1	51.5	36.4			
29 June	6	65		12.3	26.2	41.5	20.0		
16 Aug.	6	98	3.1	39.8	3.1	35.7	18.4		
Rana sphenocephala									
4 May	7	338	0.5	55.3	42.9	1.2			
9 June	7	53		24.5	56.6	18.9			
19 June	7	10		60.0	20.0	10.0	10.0		
19 May	H	15		46.7	53.3				
9 June	H	70		37.1	40.0	22.9			
29 June	H	3		33.3	67.7				
9 June	2	33		33.3	48.4	18.2			
9 June	15	74		13.5	36.4	45.9	4.1		

observations were of tadpoles captured in minnow traps and juveniles captured in pitfall traps. Three juveniles were captured in small mammal snap traps, presumably when they tried to eat insects on the bait. Series of tadpoles from three ponds illustrate changes in development over a period of several weeks (Table 2). Juveniles were captured in pitfall traps in early successional, pine, and mixed hardwood and pine habitats. Metamorphs with tails (stage V) were found on 29 June. The largest individual measured was a female at 72 mm SVL and 31 g.

Scaphiopus holbrookii (8)

One adult and 7 juveniles were captured on 18 May and 9 and 28 June in the pine plantation.

Lizards

Eumeces inexpectatus (8, 15)

One juvenile was captured in the pine plantation and one was observed under a board in a grassy area under a power line.

Scincella lateralis (12, 16)

All three adult skinks were observed in the mixed hardwood and pine habitat.

Snakes

Coluber constrictor constrictor (11)

One adult female (930 mm, 295 g) was found crawling over a debris pile next to an abandoned building in mixed hardwood and pine habitat on 3 May. This snake was in the process of ecdysis.

Diadophis punctatus punctatus (10)

One adult non-gravid female (210 mm SVL, 3.4 g) with normal pattern was found under a piece of shingle next to an abandoned building in mixed hardwood and pine habitat on 3 May.

Nerodia sipedon sipedon (2, 7, Horseshoe)

Several adults were caught in minnow traps, all in May. The largest snake measured was a male at 835 mm SVL and 598 g.

Thamnophis sauritus sauritus (2)

One adult female (511 mm SVL, 59 g) was found along the grassy margin of a small, shallow pond on 18 May.

Turtles

Chrysemys picta picta (2, 15)

One juvenile was captured in a minnow trap in a small, isolated pond. An adult female (140 mm CL) was caught on 8 June about 20 m from a vernal pool, apparently returning from nesting as the posterior portion of her shell was covered with mud.

Chelydra serpentina serpentina (2, 6, 15, Horseshoe, James River)

An adult was observed basking on a log in a shallow pond on 3 May. Another was observed as it crawled from the beach into the James River on 18 May.

Kinosternon subrubrum subrubrum (2, 5, 7, 13)

Two juveniles were captured in minnow traps in a small pond on 19 May and 16 August. One emaciated adult male (102 mm CL, 158 g) was found in the floodplain of a small tributary leading to a small pond, and one adult was found in a pitfall trap in an early successional habitat.

Malaclemys terrapin terrapin (10)

The shell of a dead male (116 mm CL) was found on the bank of the James River on 18 May.

Pseudemys rubriventris (6)

Several adults were observed basking in a pond on 3 May. One road-killed adult male (239 mm PL) was found about 0.8 km south of the site on State Rt. 135.

Terrapene carolina carolina (6, 14, 15, 16, Horseshoe, Steamout)

Juveniles and adults were found in mixed hardwood and pine and hardwood forest habitats, all in June and August. Three individuals were found at the edges of ponds in August. One of these was found dead floating in the water. The largest was a male measuring 137 mm CL, 134 mm PL, and 476 g.

Mammals

Blarina brevicauda (8, 13, Horseshoe)

Most adults were captured on 19 May and 9 June in the pine plantation, one was caught on 9 June in mixed hardwoods, and one was in a pitfall trap in an early successional habitat on 15 August.

Cryptotis parva (14)

One least shrew was caught in a pitfall trap in an old-field habitat on 19 May.

Glaucomys volans (12)

One adult male was caught in a snap trap (later released unharmed) in the mixed hardwood and pine pitfall trap habitat on 4 May.

Lasiurus borealis (12)

One male (105 mm total length, 309 mm wingspan, 38 mm forearm length, 10 g) and one female (119 mm total length, 336 mm wingspan, 41 mm forearm length, 13 g) were captured on 18 May in mixed hardwood and pine habitat.

Mus musculus (7, 13)

One male was caught in a snap trap in the grass field around site 7 on 4 May. Another (male?) was caught in an old field on 19 May.

Peromyscus leucopus (3, 6, 13, 14, Horseshoe, Steamout)

This common species was captured in early successional, mixed hardwood and pine, and hardwood habitats.

Ochrotomys nuttalli (14)

One male was captured in a snap trap in an early successional site on 4 May.

Reithrodontomys humulis (14)

One female was captured in a snap trap in an early successional site on 4 May.

Sigmodon hispidus (13)

One individual was captured in a snap trap in an early successional on 19 May.

DISCUSSION AND CONCLUSIONS

The absence of herbaceous plants on the forest floor in the majority of sites we sampled suggests that the vegetation community on the FNOD site is substantially altered from that expected for natural communities in this area. Robust communities of understory herbs occur in natural habitats in surrounding areas. However, the lack of herbs on the FNOD site was pronounced and may have a negative impact on terrestrial vertebrates, especially small mammals that depend on herbaceous plant matter as a supplement to seasonally produced seeds and mast. Some invasive vines (e.g., Japanese honeysuckle) commonly use disturbed (open) areas, but are able to prosper in the low-light environment of the forest infrastructure (Carter et al., 1989). They were common on the forest floor of many of our study sites. Colonization of understory herbs in this area was hindered by the historical use of the FNOD site, the unusually high incidence of vines, and perhaps some other factor, such as contamination or the widespread presence of the human-derived gravel layer under the recently deposited topsoil. Other species that do well in disturbed habitats (e.g., mimosa, hackberry, poison ivy, multiflora rose) were commonly encountered on the FNOD site. Thus, our study encompassed habitats in a heavily disturbed landscape.

The amphibian and reptile faunas in the FNOD site consisted of common and widely distributed species that would be expected in ecologically altered landscapes. All of them are widespread in Virginia and eastern North America (Conant & Collins, 1998; Mitchell & Reay, 1999). American bullfrogs, northern green frogs, southern leopard frogs, and southern toads are well-known inhabitants of disturbed habitats in urban and suburban areas (Wright & Wright, 1949; JCM, pers. obs.). The presence of sandy soils in the pine plantation allowed the uncommonly discovered eastern spadefoots to persist in this area. Treefrogs are closely tied to ephemeral wetlands and require surrounding forested habitat to persist. They disperse widely (Dodd, 1996; Semlitsch, 1998) and may have colonized some areas of the FNOD site since military operations ceased. No terrestrial or aquatic salamanders were found on this site, suggesting that they were extirpated and have not colonized the area since it was occupied by the military. The terrestrial lizards and snakes documented on the FNOD site are known to occur in urban and altered areas as long as there is food and shelter and have not been extirpated locally. The southern ring-necked snake is the only species we discovered that is closely tied to forested habitats (Mitchell, 1994), suggesting that some natural habitat remained on the FNOD site through is occupation. With the exception of the estuarine diamond-backed terrapin, all of the turtle species we encountered are found in other urban and disturbed habitats in Virginia (Mitchell, 1994). Thus, the herpetofauna of the FNOD site is similar to those in urbanized and other disturbed areas in southeastern Virginia.

The small mammal community also consists of widespread species known to use fragmented habitats in degraded landscapes. Small mammal species richness and diversity in early successional habitats were higher in the FNOD site compared to other habitats sampled because of microhabitat preferences. Species (excluding bats) fell into two categories, (1) early successional habitat specialists (least shrew, eastern harvest mouse, hispid cotton rat) (Dunaway, 1968; Pagels, 1977; Pagels et al., 1992), and (2) habitat generalists (white-footed mouse, northern short-tailed shrew, house mouse) (Miller & Getz, 1977; Dueser & Shugart, 1979; Adler, 1985; Pagels et al., 1992; Linzey, 1998). Two species, the golden mouse and southern flying squirrel, are nearly always encountered in forested habitats (Golley et al., 1965; Cothran et al., 1991; Linzey, 1998). All of the generalist species occur in early successional habitats, as well as in habitats dominated by hardwood forests.

No listed (state or federal) species were found during our inventory. Only the diamond-backed terrapin, considered a Federal Species of Concern (U.S. Fish and Wildlife Service), was discovered during this study.

Two food webs can be identified on the FNOD site, one in wetlands and one in terrestrial habitats. Interactions between the food webs and between food webs in different terrestrial habitats occur through movements of individuals and by eggs deposited on land by largely aquatic species (e.g., turtles). Identification of the components of these food webs would allow us to target those species most useful for ecotoxicological evaluations. The terrestrial vertebrate food web consists of adult and juvenile frogs, watersnake and black racer predators, and a variety of mammals and birds which prey upon the frogs and snakes. Several of these species would make excellent models for the uptake and movement of environmental contaminants in the FNOD site. The tadpole life history stage of frogs in this region are primary consumers in freshwater wetlands and may carry contaminants into terrestrial food webs following metamorphosis and dispersal. The only common to abundant mammal at this site that may be useful for evaluation of environmental contamination is the white-footed mouse. These mice eat vegetation and seeds that could transfer contaminants from contaminated soil.

Interstate 664 may fragment populations of these wetland and terrestrial vertebrates into two different communities. Few amphibians, reptiles, or small mammals are likely to move successfully across this heavily traveled road. Contaminated animals in these three vertebrate classes, if there are any, are not very likely to move from one side to the other. Thus, with the exception of birds of prey, crows, vultures, or some mid-sized mammals that feed on these smaller animals, the terrestrial vertebrate community food webs east and west of I-664 should be viewed as separate entities. Rates of movement of predatory or carrion-feeding species across the interstate should be taken into consideration in risk assessment models.

ACKNOWLEDGMENTS

We thank AH Environmental Consultants, Inc. and the Army Corps of Engineers for financial support of this study.

LITERATURE CITED

Adler, G. H. 1985. Habitat selection and species interactions: an experimental analysis with small mammal populations. Oikos 45: 380-390.

Alford, R. A., & S. J. Richards. 1999. Global amphibian declines: A problem in applied ecology. Annual Review of Ecology and Systematics 30: 133-165.

Breidling, F. E., F. P. Day, Jr., & R. K. Rose. 1983. An evaluation of small rodents in four Dismal Swamp plant communities. Virginia Journal of Science 34: 14-28.

Buhlmann, K. A., J. C. Mitchell, & C. A. Pague. 1994. Amphibian and small mammal abundance and diversity in saturated forested wetlands and adjacent uplands of southeastern Virginia. Pp. 1-7 *In* S. D. Eckles, A. Jennings, A. Spingarn, & C. Wienhold (eds.) Proceedings of a Workshop on Saturated Forested Wetlands in the Mid-Atlantic Region: The State of the Science. U.S. Fish and Wildlife Service, Annapolis, MD.

Carter, G. A, A. H. Teramura, & I. N. Forseth. 1989. Photosynthesis in an open field for exotic versus native vines in the southern United States. Canadian Journal of Botany 67: 443-446.

Conant, R., & J. T. Collins. 1998. A Field Guide to Reptiles and Amphibians, Eastern and Central North America. Third expanded edition. Houghton Mifflin Co., Boston, MA. 616 pp.

Cothran, E. G., M. H. Smith, J. O. Wolff, & J. B. Gentry. 1991. Mammals of the Savannah River Site. Publication #SRO-NERP-21, Savannah River Site National Environmental Research Park Program. 191 pp.

Dodd, C. K., Jr. 1996. Use of terrestrial habitats by amphibians in the sandhill uplands of north-central Florida. Alytes 14: 42-52.

Dueser, R. D., & H. H. Shugart. 1979. Niche pattern in a forest floor small mammal fauna. Ecology 60: 108-118.

Dunaway, P. B. 1968. Life history and population aspects of the eastern harvest mouse. American Midland Naturalist 79: 48-76.

Erdle, S. Y., & J. F. Pagels. 1995. Observations on *Sorex longirostris* (Mammalia: Soricidae) and associates in eastern portions of the historical Great Dismal Swamp. Banisteria 6: 17-23.

Gibbons, J. W., D. E. Scott, T. J. Ryan, K. A. Buhlmann, T. D. Tuberville, B. S. Metts, J. L. Greene, T. Mills, Y. Leiden, S. Poppy, & C. T. Winne. 2000. The global decline in reptiles, déjà vu amphibians. BioScience 50: 653-666.

Golley, F. B., J. B. Gentry, L. D. Caldwell, & L. B. Davenport, Jr. 1965. Number and variety of small mammals on the AEC Savannah River Plant. Journal of Mammalogy 46: 1-18.

Gosner, K. L. 1960. A simplified table for staging anuran embryos and larvae with notes on identification. Herpetologica 16: 183-190.

Linzey, D. W. 1998. The Mammals of Virginia. McDonald and Woodward Publishing Co., Blacksburg, VA. 459 pp.

Miller, D. H., & L. L. Getz. 1977. Factors influencing local distribution and species diversity of forest small mammals in New England. Canadian Journal of Zoology 55: 806-814.

Mitchell, J. C. 1994. The Reptiles of Virginia. Smithsonian Institution Press, Washington, DC. 352 pp.

Mitchell, J. C., S. Y. Erdle, & J. F. Pagels. 1998. Notes on the ecology and distribution of some amphibians and reptiles in southeastern Virginia. Banisteria 11: 41-46.

Mitchell, J. C., & C. A. Pague. 1991. Ecology of freshwater turtles in Back Bay, Virginia. Pp. 183-187 *In* H. G. Marshall & M. D. Norman (eds.), Proceedings of the Back Bay Ecological Symposium. Old Dominion University, Norfolk, VA.

Mitchell, J. C., C. A. Pague, & D. J. Schwab. 2000. Herpetofauna of the Great Dismal Swamp. Pp. 155-174 *In* R.K. Rose (ed.), The Natural History of the Great Dismal Swamp. Old Dominion University Publications, Norfolk, VA.

Mitchell, J. C., & K. K. Reay. 1999. Atlas of Amphibians and Reptiles in Virginia. Special Publication Number 1, Virginia Department of Game and Inland Fisheries. Richmond, VA. 122 pp.

Pagels, J. F. 1977. Distribution and habitat of the cotton rat (*Sigmodon hispidus*) in central Virginia. Virginia Journal of Science 28: 133-135.

Pagels, J. F., S. A. Erdle, K. L. Uthus, & J. C. Mitchell. 1992. Small mammal diversity in forested and clearcut habitats in the Virginia Piedmont. Virginia Journal of Science 43: 171-176.

Pague, C. A., & J. C. Mitchell. 1991. The amphibians and reptiles of Back Bay, Virginia. Pp. 159-166 *In* H. G. Marshall & M. D. Norman (eds.), Proceedings of the Back Bay Ecological Symposium. Old Dominion University, Norfolk, VA.

Rose, R. K., R. K. Everton, J. F. Stankavich, & J. W. Walke. 1990. Small mammals in the Great Dismal Swamp of Virginia and North Carolina. Brimleyana 16: 87-101.

Semlitsch, R. D. 1998. Biological delineation of terrestrial buffer zones for pond-breeding salamanders. Conservation Biology 12: 1113-1119.

Wright, A. H., & A. A. Wright. 1949. Handbook of Frogs and Toads of the United States and Canada. Cornell University Press, Ithaca, NY. 640 pp.

Banisteria, Number 17, 2001
© 2001 by the Virginia Natural History Society

An Update to the Survey of Macrolepidopteran Moths Near Vontay, Hanover County, Virginia

J. Christopher Ludwig

Virginia Department of Conservation and Recreation
Division of Natural Heritage
217 Governor Street
Richmond, Virginia 23219

INTRODUCTION

This paper updates the list of macrolepidopteran moth (= "macro moth" or "macro") species collected at a site on the Virginia Piedmont, 2 km W of Vontay in western Hanover County. The study site, methodology, and original species list are given in Ludwig (2000). The list is updated with new collections as well as identifications of additional specimens collected during the original study period. The new collections extend the study period from two years (30 October 1996 to 28 October 1998) to nearly four years (30 October 1996 to 14 September 2000) and increase the number of collection nights from 311 to >400. The species list from this study, along with others being gathered throughout Virginia by the Virginia Department of Conservation and Recreation's Division of Natural Heritage, is being used to ascertain the biological status and develop a complete list of the Commonwealth's macrolepidopteran moths.

RESULTS AND DISCUSSION

A total of 190 macroleptidopteran moth specimens was pinned and identified during the extended study period, bringing the total number of collected specimens at this site to 2,088. These collections increased the number of species documented at this site from 492 to 521 and the number of genera from 286 to 298. (Table 1 and Appendix). The Noctuidae (306 species) and Geometridae (101) were most diverse with the Arctiidae (34) and Notodontidae (32) also rich.

Using a checklist of confirmed and possible macro-moths from Virginia (Virginia Division of Natural Heritage, unpub. data) numbering 1314 species, one estimate of the percentage of the Commonwealth's macroleptidopteran fauna represented at the Vontay site is about 39%. If the Noctuidae of Virginia are similar in richness to the noctuid faunas of Ohio (Rings et al., 1992) and Kentucky (Covell, 1999) with 708 and 616 species, respectively, an estimate of the percentage of the Commonwealth's noctuid fauna represented at the Vontay site is about 43 to 49%.

An updated species-accumulation curve (Fig. 1) for this study indicates that additional macros will be recorded at the site should collections continue. Depending upon the projected trajectory of the curve, estimates of the total number of taxa recorded from this site over 10 years range from 560 to 660 macro-moth species, representing perhaps as much as 50% of the state's estimated total macro fauna.

Table 1. Summary of macro-moths encountered during this study by family given in order of Hodges et al. (1983).

FAMILY	NO. OF GENERA	NO. OF SPECIES	NO. OF SPECIMENS
Thyatiridae	2	2	9
Drepanidae	3	3	6
Geometridae	69	101	382
Epiplemidae	2	2	5
Mimallonidae	1	1	6
Apatelodidae	2	2	4
Lasiocampidae	4	5	8
Saturniidae	10	11[a]	10
Sphingidae	12	17[b]	32
Notodontidae	17	32	135
Arctiidae	18	34	93
Lymantriidae	2	5	21
Noctuidae	158	306	1377
TOTALS	298	521	2088

[a] Five species documented by sight records only
[b] One species documented by sight record only

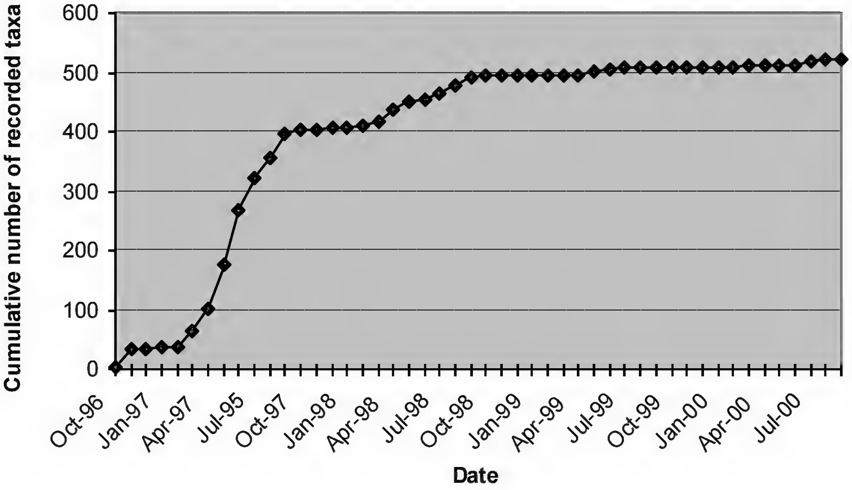


Figure 1. Species accumulation curve for macrolepidopteran moths collected near Vontay, Virginia.

ACKNOWLEDGMENTS

Rebecca Wilson assisted with fieldwork. Steve Roble assisted with identifications and recruited help with determinations from knowledgeable lepidopterists including Doug Ferguson, Steve Hall, Eric Quinter, Dale Schweitzer, and Bo Sullivan. Manuscript preparation was funded in part by the Virginia Department of Conservation and Recreation, Division of Natural Heritage. All specimens are currently housed in the DNH reference collection.

LITERATURE CITED

Covell, C. V., Jr. 1999. The Butterflies and Moths (Lepidoptera) of Kentucky: An Annotated Checklist. Kentucky State Nature Preserves Commission, Scientific and Technical Series 6. 220 pp.

Hodges, R. W., T. Dominick, D. R. Davis, D. C. Ferguson, J. G. Franclemont, E. G. Munroe, & J. A. Powell. 1983. Check List of the Lepidoptera of America North of Mexico. E. W. Classey Ltd. & The Wedge Entomological Foundation, London. 284 pp.

Ludwig, J. C. 2000. A survey of macrolepidopteran moths near Vontay, Hanover County, Virginia. Banisteria 15: 16-35.

Rings, R. W., E. H. Metzler, F. J. Arnold, & D. H. Harris. 1992. The Owlet Moths of Ohio Order Lepidoptera Family Noctuidae. Ohio Biological Survey Bulletin. New Series 9 (2). 219 pp.

Appendix. Additional macro moth species identified during this study given in order of Hodges et al. (1983). Fields are: checklist number, species name, collection date (month/day/year), method (s = sugar bait, b = black light, i = incandescent light, m = mercury vapor light); numbers in parentheses indicate if the number of specimens is >1 for a given date and survey method. A ? is added if the specimen identification was not confirmed by Ferguson, Hall, Quinter, or Schweitzer. Asterisks denote species new for the study.

Geometridae

06386	*Semiothisa ocellinata* (Gn.)	05/05/99 i
06443	*Glenoides texanaria* (Hulst)	04/05/00 i
06452	*Glena plumosaria* (Pack.)	05/22/99 i
06590	*Anavitrinelia pampinaria* (Gn.)	07/05/99 m, 07/24/99 m
*06663	*Palaecrita merriccata* Dyar	02/14/99 i ?
06726	*Euchlaena obtusaria* (Hbn.)	05/13/99 m (2)
06733	*Euchlaena amoenaria* (Gn.)	08/15/00 m
*06733a	*Euchlaena astylusaria* (Wlk.)	08/26/00 m
06763	*Nacophora quernaria* (J.E.Sm.)	05/21/99 m
06796	*Campaea perlata* (Gn.)	09/11/00 m
06836	*Anagoga occiduaria* (Wlk.)	05/07/99 m
06844	*Plagodis alcoolaria* (Gn.)	07/04/99 m, 04/01/00 b
*06884	*Besma endropiaria* (Grt.&Rob.)	05/21/99 m
06941	*Eusarca confusaria* Hbn.	06/06/99 m
07071	*Chlorochlamys chloroleucaria* (Gn.)	07/11/99 i
07075	*Chloropteryx tepperaria* (Hulst)	07/11/99 m
*07094	*Lobocleta ossularia* (Gey.)	05/12/99 m
07114	*Idaea demissaria* (Hbn.)	06/05/99 m, 06/11/99 i, 07/30/00 m
*07123	*Idaea obfusaria* (Wlk.)	07/02/99 m, 07/15/99 i
07132	*Pleuroprucha insulsaria* (Gn.)	06/26/99 m, 07/24/99 m (2)
07159	*Scopula limboundata* (Haw.)	07/05/99 m
07169	*Scopula inductata* (Gn.)	07/29/00 m ?
07179	*Leptostales rubromarginaria* (Pack.)	05/09/99 m, 07/03/99 m
07196	*Eulithis diversilineata* (Hbn.)	07/22/99 m
07416	*Costaconvexa centrostrigaria* (Woll.)	04/08/99 m, 03/08/00 i
07417	*Disclisioprocta stellata* (Gn.)	10/10/99 i
*07422	*Hydrelia inornata* (Hulst)	03/02/97 i ?
*07639	*Cladara atroliturata* (Wlk.)	03/02/97 i, 03/29/97 i

Epiplemidae

07653	*Calledapteryx dryopterata* Grt.	07/29/98 m

Mimallonidae

07659	*Lacosoma chiridota* Grt.	07/03/99 m

Sphingidae

*07784	*Dolba hyloeus* (Dru.)	07/25/00 i
07824	*Paonias excaecatus* (J.E.Sm.)	07/31/00 m
*07826	*Paonias astylus* (Dru.)	07/29/00 m
07886	*Darapsa pholus* (Cram.)	08/02/00 m

Notodontidae

07929	*Nerice bidentata* Wlk.	05/13/99 m
07975	*Macrurocampa marthesia* (Cram.)	07/24/99 m
07990	*Heterocampa umbrata* Wlk.	07/01/99 m
07999	*Lochmaeus bilineata* (Pack.)	06/15/00 i
08005	*Schizura ipomoeae* Doubleday	07/05/99 m
08007	*Schizura unicornis* (J.E.Sm.)	06/06/99 m, 07/25/00 i
*08022	*Hyparpax aurora* (J.E.Sm.)	07/26/99 m

Arctiidae

08046	*Crambidia uniformis* Dyar	10/20/99 i
08053x	*Crambidia cephalica* (Grt.&Rob.) complex	08/03/99 m
08072	*Cisthene packardii* (Grt.)	06/06/99 m
*08104	*Comachara cadburyi* Franc.	05/02/99 m, 05/08/99 i
08140	*Hyphantria cunea* (Dru.)	06/10/99 m
08176	*Grammia anna* (Grt.)	06/06/99 m
08231	*Cycnia oregonensis* (Stretch)	05/11/99 i
08267	*Cisseps fulvicollis* (Hbn.)	09/04/00 m

Noctuidae

08327	*Idia forbesi* (French)	06/06/99 s
*08329	*Idia diminuendis* (B.&McD.)	06/04/99 m, 06/05/99 i
08334	*Idia lubricalis* (Gey.)	07/01/99 s
08345	*Zanclognatha laevigata* (Grt.)	07/29/00 m
08358	*Macrochilo litophora* (Grt.)	06/10/99 m
08364	*Phalaenostola larentioides* Grt.	05/21/99 m, 06/05/99 m, 07/23/99 m
*08381	*Renia discoloralis* Gn.	07/24/99 m ?
08401	*Redectis vitrea* (Grt.)	06/15/00 i ?, 08/24/00 m ?
*08411	*Colobochyla interpuncta* (Grt.)	05/08/99 m
08443	*Bomolocha bijugalis* (Wlk.)	04/30/00 i
08447	*Bomolocha madefactalis* (Gn.)	05/16/99 m, 06/04/99 m, 08/15/00 m
08465	*Plathypena scabra* (F.)	07/24/99 m
08479	*Spargaloma sexpunctata* Grt.	05/21/99 m, 07/29/99 m
08490	*Pangrapta decoralis* Hbn.	06/12/99 i
08502	*Metalectra tantillus* (Grt.)	08/26/00 m
08505	*Metalectra richardsi* Brower	08/15/00 m
08514	*Scolecocampa liburna* (Gey.)	08/05/00 m
*08523	*Gabara distema* (Grt.)	08/22/97 i
08591	*Phoberia atomaris* Hbn.	03/24/00 i
08651	*Lesmone detrahens* (Wlk.)	05/12/99 m, 06/06/99 s
*08699	*Zale obliqua* (Gn.)	03/08/00 i, 05/10/00 i
08705	*Zale bethunei* (Sm.)	04/08/99 m, 07/24/99 m, 03/09/00 i, 3/25/00 i, 06/11/00 i
08707	*Zale metatoides* McD.	06/03/99 m ?
08745	*Mocis texana* (Morr.)	06/11/99 m
08769	*Spiloloma lunilinea* Grt.	07/01/00 i
08771	*Catocala piatrix* Grt.	09/04/00 m (2)
08773	*Catocala epione* (Dru.)	07/29/00 m
*08790	*Catocala dejecta* Stkr.	08/05/00 m ?

Noctuidae (continued)

08792	*Catocala vidua* (J.E.Sm.)	08/01/00 m
08801	*Catocala ilia* (Cram.)	07/02/99 s, 08/01/99 m
08851	*Catocala coccinata* Grt.	07/15/99 m
08872	*Catocala clintoni* Grt.	06/12/00 i
08898	*Allagrapha aerea* (Hbn.)	09/12/00 m
08904	*Chrysanympha formosa* (Grt.)	06/05/99 m
08959	*Paectes pygmaea* Hbn.	06/03/99 m, 06/13/99 i
08975	*Nycteola frigidana* (Wlk.)	03/09/00 i ?
08983.2	*Meganola spodia* Franc.	05/17/99 m, 06/05/99 m
08990	*Nola cilicoides* (Grt.)	05/22/99 i
*09003	*Tripudia quadrifera* (Zell.)	05/13/99 m
09037	*Hyperstrotia pervertens* (B.&McD.)	08/18/00 m, 08/24/00 m
09038	*Hyperstrotia villificans* (B.&McD.)	05/12/99 m, 05/12/99 m ?, 06/06/99 m ?, 06/10/99 m, 06/12/99 i
*09039	*Hyperstrotia flaviguttata* (Grt.)	07/30/00 m
09044	*Thioptera nigrofimbria* (Gn.)	06/13/99 m
09047	*Lithacodia muscosula* (Gn.)	06/28/98 i, 06/03/99 m
09051	*Lithacodia musta* (Grt.&Rob.)	06/13/99 m
09057	*Homophoberia apicosa* (Haw.)	06/05/99 m
*09136	*Acontia aprica* (Hbn.)	05/28/00 i
09169	*Bagisara rectifascia* (Grt.)	06/10/99 m
09189	*Charadra deridens* (Gn.)	08/15/00 m
*09193	*Raphia frater* Grt.	06/13/99 m
09208	*Acronicta betulae* Riley	07/25/99 m
09243	*Acronicta ovata* Grt.	07/29/00 m
09244	*Acronicta modica* Wlk.	05/09/99 m
09250x	*Acronicta inclara* Sm. complex	08/04/00 m
09251	*Acronicta retardata* (Wlk.)	05/17/99 m
09254	*Acronicta afflicta* Grt.	05/13/99 m, 06/06/99 m, 08/14/00 m (2)
09264	*Acronicta longa* Gn.	08/02/00 m
*09286	*Harrisimemna trisignata* (Wlk.)	05/09/99 m
09454	*Amphipoea velata* (Wlk.)	06/13/99 m
*09463	*Parapamea buffaloensis* (Grt.)	09/14/00 m
09466	*Papaipema cataphracta* (Grt.)	11/01/99 i
*09618	*Phosphila turbulenta* Hbn.	08/25/00 m
09619	*Phosphila miselioides* (Gn.)	07/02/99 s
09669	*Spodoptera ornithogalli* (Gn.)	08/26/00 m
09678	*Elaphria versicolor* (Grt.)	08/09/00 m
*09679	*Elaphria chalcedonia* (Hbn.)	11/19/99 i
09681x	*Elaphria festivoides* (Gn.) complex	05/02/99 m, 11/05/99 i, 09/04/00 m
09690	*Condica videns* (Gn.)	04/08/99 m, 07/26/99 m
09699	*Condica sutor* (Gn.)	11/01/99 i
09720	*Ogdoconta cinereola* (Gn.)	06/08/00 i
*09930	*Pyreferra citrombra* Franc.	04/03/99 m
09941	*Sericaglaea signata* (French)	02/27/00 s
09957	*Sunira bicolorago* (Gn.)	09/04/00 m
10019	*Psaphida resumens* Wlk.	04/02/99 m (2), 04/03/99 m, 04/07/99 m (3)
10021	*Copivaleria grotei* (Morr.)	04/17/99 m
10288	*Orthodes detracta* (Wlk.)	06/03/99 m

Noctuidae (continued)

10368	*Lacinipolia meditata* (Grt.)	09/18/00 m
10397	*Lacinipolia renigera* (Steph.)	05/08/99 m, 06/10/99 m, 08/26/00 m
*10405	*Lacinipolia lorea* (Gn.)	06/13/99 m
10438	*Pseudaletia unipuncta* (Haw.)	10/20/99 i
10456	*Leucania adjuta* (Grt.)	08/23/00 m
10461	*Leucania ursula* (Fbs.)	09/12/00 m
10487	*Orthosia rubescens* (Wlk.)	04/03/99 m
10488	*Orthosia garmani* (Grt.)	03/08/00 i
10495	*Orthosia hibisci* (Gn.)	04/03/99 m, 04/01/00 b
10502	*Himella intractata* (Morr.)	04/03/99 m, 04/08/99 m
10532b	*Homorthodes lindseyi* (Benj.)	05/12/99 m
10567	*Ulolonche culea* (Gn.)	05/07/99 m, 05/12/99 m, 05/19/99 m
10915	*Peridroma saucia* (Hbn.)	07/25/00 i
10967	*Xestia elimata* (Gn.)	10/15/99 i
10969	*Xestia dilucida* (Morr.)	10/10/99 i
11006	*Protolampra brunneicollis* (Grt.)	07/06/99 m
*11012.1	*Noctua pronuba* (L.)	05/29/00 i
11068	*Helicoverpa zea* (Boddie)	08/01/00 m
*11117	*Schinia lynx* (Gn.)	08/01/00 m

Banisteria, Number 17, 2001
© 2001 by the Virginia Natural History Society

First Records for the Yellow Lamp Mussel (*Lampsilis cariosa*) in the Roanoke River System of Virginia

Richard L. Hoffman

Virginia Museum of Natural History
Martinsville, Virginia 24112

INTRODUCTION

By virtue of its shell shape and singular, waxy-yellow periostracum, *Lampsilis cariosa* (Say, 1817) is one of the more distinctive unionids of the Atlantic slope drainages between Nova Scotia and Georgia. In that part of the range south of the Potomac River, *L. cariosa* is largely confined to the Piedmont region, and only a few of the records cited by Johnson (1970: 384) are from localities below the Fall Line. The two collections from Virginia cited by Johnson appear to be the only published documentation for the species in this state.

Collecting efforts by personnel of the Virginia Museum of Natural History and the Division of Natural Heritage, Virginia Department of Conservation and Recreation (DNH-DCR), since 1988 have greatly improved knowledge of the instate distribution of *L. cariosa*, showing it to be not uncommon in several drainage basins but unknown from others, a familiar pattern for many unionid species. This very phenonemon of widely scattered (relictually isolated?) populations provides a special incentive for thorough sampling of as many river systems as possible, as new and unexpected finds are always possible. The case of *L. cariosa* itself provides a good example. Several years ago I found fresh shells of the species at two localities on the Pigg River in Franklin Co., Virginia, where, on the basis of then-known records, I would have considered it unlikely. Publication of this new river system and inlandmost population was deferred for years in the hope that the source population of the shells could be located, but in the face of several unsuccessful attempts and increasingly reduced time to continue the search, the information is put forward now. Perhaps the interest of other naturalists will be piqued, and additional searches stimulated.

SUMMARY OF HISTORICAL RECORDS

A brief historical survey of regional unionid surveys - with respect to *L. cariosa* - may provide background of interest. Early explorations generally failed to locate the species in Virginia:

a. *Potomac River system* [Maryland]: Monocacy River at Rt. 26 bridge, NE of Frederick (Ortmann, 1919); District of Columbia (Reardon, 1929); Potomac River from Great Falls to the District of Columbia (Johnson, 1970).

b. *Upper Rappahannock River system.* A. E. Ortmann, the Nestor of unionid studies at the onset of the 20th century, did not find the species around Remington, Fauquier Co., or Rapidan, Culpeper Co., in 1912, although he obtained seven other species.

c. *James River system.* North (now Maury) River headwaters (Calfpasture River), sampled by T. A. Conrad near Goshen in 1845. He collected eight species of unionids (Conrad, 1846), but *L. cariosa* was not among them. Ortmann waded the same water (Lexington to Goshen) in May 1912, and added two species, again without *L. cariosa* (Ortmann, 1913). Further downstream, in the Scottsville-Richmond segment of the James, Clench & Boss (1967) found eight species at several major crossings, but no *L. cariosa*. This was also the experience of David H. Stansbery (pers. comm.), who in 1966 sampled the Rivanna River and the main stem of the James River at five crossings between Scottsville and Maidens; although he found such species as *Pleurobema collina* (Conrad) in great abundance at most stations (Oho State Museum collection). During his studies of the latter species, Hove (1990) surveyed 240 sites in the middle and upper James system, finding a total of eleven species, but *L. cariosa* was not among them. This persuasive cumulative record has been confirmed repeatedly by more recent collectors in the James River basin: still no known populations of *L. cariosa.*

d. *York River system.* Pamunkey River, 2 miles N of Hanover [US Hwy 301], Hanover-Caroline cos. (Johnson: 1970). This site has been confirmed by collections both above and downstream (see records below). Riddick (1973) found *L. cariosa* at four sites in the Pamunkey drainage, the inlandmost in the South Anna River at the U. S. Hwy. 1 bridge.

e. *Chowan River system.* The only published record for this southeastern river basin is that of Johnson (1970: 384) for the Nottoway River at the U.S. Hwy. 1 bridge, 2 mi E Rawlings. Subsequent work has been successful in the Blackwater, Nottoway, and Meherrin rivers, as evident from the list of collections that follows. *Lampsilis cariosa* follows the latter two streams far headward onto the Piedmont: the Nottoway as far as the Falls, the Meherrin to its headwaters in western Lunenburg County.

f. *Roanoke River system.* The upper part of Roanoke River was sampled in Roanoke County by Ortmann in 1912, disclosing only a very depauperate fauna of three species (Ortmann, 1913). My own recent sampling in the South Fork of the Roanoke found no unionids, and only *Elliptio complanata* and *Villosa constricta* in the North Fork. Heretofore essentially NO collecting for these molluscs has been done in the entire reach of the Roanoke, or its major tributaries, between Vinton and Clarksville. Several species of interest have been found recently (DNH-DCR surveys) in the J. H. Kerr Reservoir and its smaller peripheral streams, but nothing remotely like *L. cariosa.* The discovery of that species in the Pigg River, therefore, starts to close the vast lacuna represented by the Roanoke basin, and throws it open to renewed, determined investigation.

h. *North Carolina river basins.* Johnson (1970: 384) cited localities in the Neuse, Tar, and Cape Fear river basins, some of them as far inland as Raleigh and Durham (Eno River). Clarke (l983) added localities in the Tar River, some well up on the Piedmont. Shelley (1987) recorded an additional locality each for the Haw and Deep rivers (Cape Fear basin), both on the Piedmont.

SUMMARY OF RECENT RECORDS

Potomac River basin

Shenandoah River: [Shenandoah Co.]: North Fork at Farmer's Mill, by Rte 661, 2 mi. S Mauertown, two unmatched valves, old and encrusted, 10 September 1990, M. L. Lipford (VMNH 329). An unpublished DNH-DCR occurrence data report compiled in November 1991 cites three additional finds of relict shells in the Strasburg-Mauertown reach of the North Fork. Personal searches in the South Fork near Bentonville and Grottoes disclosed no trace of *L. cariosa* (or any other unionid). The species may be extirpated in both forks of the Shenandoah, except possibly in larger tributaries or headward in the North Fork.

Goose Creek:[Loudoun Co.]: Rte 626 bridge, 2 mi. NW Middleburg, five sets, 2 November 1990, P. H. Stevenson (VMNH 1017). One of these specimens, although not differing from the others in any observable shell characters, is unusual in that the posterior half of the shells is provided with 5-6 narrow dark green lines, the only such case I have seen in Virginia material, although mentioned by Johnson (1970: 383) as occasionally present in this species.

York River basin

Pamunkey River: [Hanover-King William cos.]: Norman's Bridge, Rte 614, E of Hanover Court House, one set of worn valves, 6 September 1991, P. H. Stevenson (VMNH 578); [King William Co.]: Rte 602 landing, ca 4 mi. W Manquin, off Rte 604, one valve set, 6 September 1991, Stevenson (VMNH 577); "between Rtes 615 and 602 bridges", ca. 5 mi. S Mangohick, one live adult, 28 June 1983, State Water Control Board team (VMNH 759).

Mattaponi River: [King and Queen-King William cos.]: ca. 0.12 mi. upstream of Rte 628 bridge, six live adults and two relict shells, 19 October 1992, Stevenson (DNH-DCR data base).

Roanoke River basin

Pigg River: [Franklin Co.]: downstream of Rte 646 bridge, 2 mi. SSW Glade Hill, one set of valves, 2 April 1988 (VMNH 315); same site, two sets, 14 April 1988 (VMNH 318). Fralin Bridge, Rte 646, 2 mi. NW Truevine, one set, 27 February 1988 (VMNH 316) (all RLH).

Chowan River basin

Nottoway River: [Brunswick-Dinwiddie cos.]: Rte. 609 bridge, 6 mi. SE McKenney, one set of fresh valves, 1 October 1988 (VMNH 317); same site, one set of worn valves, 6 October 1990, M. L. Lipford, C. A. Pague, R. L. Hoffman (VMNH 321); same site, six live specimens, 24 June 1997, R. J. Neves et al. (Neves, pers. comm.). [Southampton Co.:]: one mile upstream of Rte. 653 bridge, 3 mi. SW Sebrell, one set of badly eroded valves, 23 May 1989 M.L. Lipford (VMNH 324); just below Rte. 653 bridge, live specimen, 26 September 1988, Hoffman (VMNH 755), same site, 4 June 1966, J. J. Johnson (OSM 16434). [Nottoway-Lunenburg cos.]: Below Nottoway Falls, several collections, no retentions, May and June 1990, DNH-DCR personnel. [Southampton Co.]: Rte 684 bridge, ca. 5 mi SW Franklin, one living, one set of worn valves, 24 July 1996, R. J. Neves et al (Neves, pers. comm.).

Blackwater River: [Isle of Wight Co.]: Zuni Pine Barrens, 4 mi S Zuni, one live specimen, 20 July 1991, C. A. Pague (VMNH 759).

Meherrin River: [Greensville Co.]: Emporia, eddy above CSX RR bridge, one set of valves, 20 August 1990, Lipford and Pague (VMNH 322); same site, live adult male, 14 July 1993, Hoffman (VMNH 1122). [Lunenburg Co.]: North Meherin at Rte 712 bridge, ca. 2 mi. E Traffic, three sets of valves, 11 August 1988, Hoffman (VMNH 319); same site, downstream of bridge, three live adults, 11 August 1988, Hoffman (VMNH 758); same site, one set, 26 May 1989, Hoffman (VMNH 320); same site, two sets, 6 July 1990, Lipford, Pague, Hoffman (VMNH 328); upstream of Va. Hwy. 49 bridge, 2 mi.NE Rehoboth, live adult, 18 June 1988, Hoffman (VMNH 761). Middle Meherrin at Rte. 634 bridge, 4.6 mi SSE Rehoboth (two live adults, not retained), 6 July 1990, DNH-DCR survey. South Meherrin at site of Reeks Mill, 4 mi NW Northview, two sets, 13 November 1989, Lipford and Pague (VMNH 323).

DISCUSSION

Preparation of the distribution map (Fig. 1) disclosed the interesting fact that most of the known localities are either above the limits of tidal influence in Coastal Plain streams, or in the Piedmont itself. This generalization seems to apply likewise in the Carolinas and Georgia. Further north in its range, *L. cariosa* appears to be more associated with waters under tidal influence.

The absence of *L. cariosa* from the James River system remains inexplicable, particularly when contrasted with the exclusive presence there of *Pleurobema collina* (and many endemic species of freshwater fishes). At present, *L. cariosa* seems to be present and apparently secure in only the Pamunkey, Nottoway, and Meherrin rivers. Extirpation from the Shenandoah basin seems to

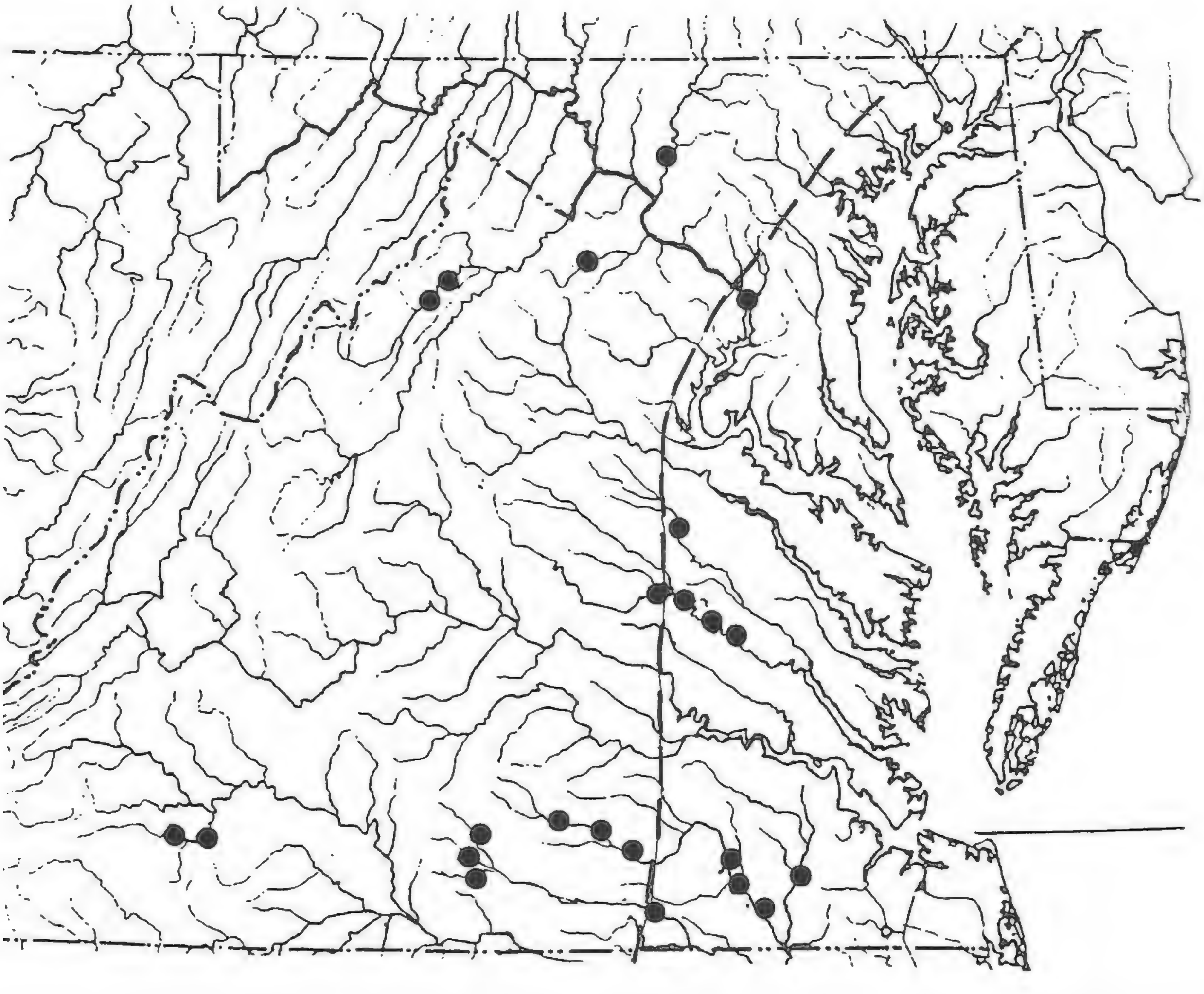


Fig. 1. Distribution of *Lampsilis cariosa* in Virginia. Several adjacent sites may be covered by one symbol. For the Potomac River system, only records based on live or freshly dead specimens are shown, owing to the possibility of confusing worn relict shells with those of *Lampsilis cardium*.

have occurred fairly recently. The status of the species in the Pigg River system invites serious investigation. Such sizeable tributaries as Big Chestnut Creek may have escaped serious contamination and now represent local refuges.

Although the present disjunct occurrence of populations of *L. cariosa* in Virginia may be due to some extent to the vagaries of glochidial transport by fish and other natural causes, the influence of adverse human impacts cannot be too strongly emphasized. Piedmont streams, which often appear optimal to the eye but are devoid of unionids, may have been terminally stressed over a century ago, when a large part of that region south of the James River was devoted to tobacco culture. Pest control at that time depended to a considerable extent on the use of lead- and arsenic-based compounds applied to tobacco leaves as dust. Inevitably, such poisons would be washed into the ground and find their way into nearby streams.

ACKNOWLEDGMENTS

I am very much indebted to Dr. David H. Stansbery (Ohio State University), for access to data from his 1966 James River surveys, and to Dr. Richard J. Neves for several Nottoway River localities established during his own field work. Early records in the DNH-DCR files were provided by Michael L. Lipford and Christopher A. Pague, and numerous collections made by VDNH zoologists since 1991 were donated to VMNH by staff zoologist Steven M. Roble.

LITERATURE CITED

Clarke, A. H. 1983. Status survey of the Tar River spiny mussel. Final Project Report to the U. S. Fish and Wildlife Service, Asheville, NC.

Clench, W. J., & K. J. Boss, 1957. Freshwater Mollusca from James River, Virginia. Nautilus 80: 99-101.

Conrad, T. A. 1846. Notices of fresh water shells, &c., of Rockbridge County, Virginia. American Journal of Science, series 2, 1 (3): 405-407.

Hove, M. C. 1990. Distribution and life history of the endangered James Spinymussel, *Pleurobema collina* (Bivalvia: Unionidae). Master's Thesis, Virginia Polytechnic Institute and State University, Blacksburg, VA. 112 pp.

Johnson, R. I. 1970. The systematics and zoogeography of the Unionidae (Mollusca: Bivalvia) of the Southern Atlantic Slope. Bulletin of the Museum of Comparative Zoology 140: 263-450.

Ortmann, A. E. 1913. The Alleghenian Divide and its influence upon the freshwater fauna. Proceedings of the American Philosophical Society 52: 287-390.

Ortmann, A. E. 1919. A monograph on the naiades of Pennsylvania. Part 3. Systematic account of the genera and species. Memoirs of the Carnegie Museum 8: i-xiv, 1-384.

Reardon, L. 1929. A contribution to our knowledge of the anatomy of the fresh-water mussels of the District of Columbia. Proceedings of the United States National Museum 75(11): 1-11, pls. 1-5.

Riddick, M. B. 1973. Freshwater mussels of the Pamunkey River system, Virginia. Master's Thesis, Virginia Commonwealth University, Richmond, VA. 105 pp.

Shelley, R. M. 1987. Unionid mollusks from the upper Cape Fear River basin, North Carolina, with a comparison of the faunas of the Neuse, Tar, and Cape Fear drainages (Bivalvia: Unionacea). Brimleyana 13: 67-89.

Banisteria, Number 17, 2001
© 2001 by the Virginia Natural History Society

Loggerhead Sea Turtle Late Nesting Ecology in Virginia Beach, Virginia

Chad L. Cross[1,3]

Department of Biological Sciences
Old Dominion University
Norfolk, Virginia 23529

John B. Gallegos, Florence G. James[2]

U.S. Fish and Wildlife Service
Back Bay National Wildlife Refuge
4005 Sandpiper Road
Virginia Beach, Virginia 23456

The loggerhead sea turtle (*Caretta caretta*) is the only recurrent nesting species of sea turtle in southeastern Virginia (Lutcavage & Musick, 1985; Dodd, 1988). Inasmuch as the loggerhead is a federally threatened species, the opportunity to gather data on its nesting ecology is important for establishing appropriate management strategies.

Loggerhead females deposit eggs on a 2-4 year cycle, and produce an average of 1-7 nests in any one breeding season (Ehrhart, 1979; Dodd, 1988; Ernst et al., 1994). Nesting in southeastern Virginia generally occurs from late May through July, with an occasional nest produced in August. Data from other locations in the southeastern United States indicate that eggs incubate for an average of 60-65 days (range = 59-78) in natural and transplanted nests (Ernst et al., 1994), and from 70-85 days in hatchery-reared nests (Mrosovsky & Yntema, 1980; Blanck & Sawyer, 1981).

Temperature-dependent sex determination in loggerheads is well documented (Mrosovsky & Yntema, 1980; Standora & Spotila, 1985; Mrosovsky & Provancha,1989, 1992). Studies of loggerheads in Florida by Mrosovsky & Provancha (1989, 1992) suggest that hatchling ratios are strongly female-biased, and Georgia and South Carolina populations produce female-biased hatchlings (Mrosovsky et al., 1984). Pivotal incubation temperatures are 29-30 C; males are produced at cooler temperatures and females at warmer temperatures (Mrosovsky & Provancha, 1992). Given the generally cooler temperatures found in northern climates, it is possible that loggerhead nests in southeastern Virginia (where mean sand temperatures are approximately 27-28 C) are a source of male hatchlings (DeGroot & Shaw, 1993).

Data on loggerhead nesting ecology on the beaches of Back Bay National Wildlife Refuge (BBNWR), Virginia Beach, Virginia and adjacent beaches immediately north and south of BBNWR have been gathered since 1970. Beginning in 1993, funding from the U. S. Army Corps of Engineers, Norfolk, Virginia, has provided salaries for trained U. S. Fish and Wildlife Service personnel at BBNWR to conduct daily patrols along a 16-24 km stretch of beach from May through August. Patrol personnel searched for turtle crawls and nests. Environmental data (e.g., temperature of air and sand,

---

[1] Present address of CLC: U.S. Environmental Protection Agency, ORD/NERL, Landscape Ecology Branch, P. O. Box 93478, Las Vegas, Nevada 89193; email: cross.chad@epa.gov

[2] Present address of FGJ: U.S. Fish and Wildlife Service, Long Island National Wildlife Refuge Complex, P. O. Box 21, Shirley, New York 11967

[3] Corresponding author

weather conditions, and location), as well as data on turtle crawl dimensions (e.g., length and width), were taken at the nesting site. All nests were then excavated and the eggs transported to a protected beach location at BBNWR where they were placed in an artificial nest with the identical dimensions as the original and in the same intra-nest location (i.e., egg deposition order was maintained) from which they were collected (DeGroot & Shaw, 1993; Cross et al., 1998).

Given the cool temperatures associated with the incubation of loggerhead eggs in southeastern Virginia (DeGroot & Shaw, 1993), clutches produced in the month of August ("late nests") were at risk due to excessively cold temperatures through October, when hatchlings would be expected to emerge. To reduce nesting mortality, late nests were excavated from their protected location (generally during September), placed into artificial nesting containers, and removed to a heated building. The sand in the nest was maintained at approximately 27-28 C, which represented the temperature of a natural nest on the BBNWR beach. Hatchlings from these nests were later released at their natal beach (Cross et al., 1998). It should be noted that we were not providing a "head-start" program, as was strongly recommended against by Frazer (1992); turtles were released immediately after hatching.

Hatching success was high for the 1995 late nest, and for the first late nest of 1996; however, the second late nest of 1996 had low hatching success (Table 1). It should be noted, however, that all fertile eggs hatched (by inspection of all eggs in the nest), and that all hatchlings were vigorous upon release.

Because of cool sand temperatures in September, the incubation period was nearly 20 days longer than average for late nests (1995 mean = 62 days, n = 8; 1995 late nest = 81 days; 1996 late nests = 80 and 81 days -- these were the only two nests produced in 1996). The incubation period associated with eggs exposed to cool temperatures lasts as long as 3.5 months, resulting in very low hatching success (Blanck & Sawyer, 1981). Moving the eggs to an artificial incubation chamber when sand temperatures were low (<23 C) for 2-3 consecutive days greatly increased hatching success. The additional 20 days of incubation time did not appear to affect hatching success.

Mean incubation temperatures were below the pivotal range of 29-30 C reported by Mrosovsky & Provancha (1991) for loggerheads in the southeastern United States, suggesting that southeastern Virginia may be an important source of male hatchlings. However, no hatchlings were sacrificed to determine sex and we can only speculate that the majority of hatchlings from BBNWR were males. Of course, to maintain a nesting population, some females must also be produced, and the recurrent nesters at BBNWR provide evidence that this is the case.

The decision to move nests to a protected location at BBNWR was based on our belief that a sound management strategy for the loggerhead was to ensure that we maximized the number of hatchlings produced while striving for management activities that would reduce natural mortality in this species. Though this type of active management activity is controversial, we believe our strategy is justified for several reasons: (1) The beaches at BBNWR are very narrow compared to more southern nesting locations. Therefore, there is a high

TABLE 1.—Late nesting data for the loggerhead sea turtle (*Caretta caretta*) in 1995 and 1996 at Back Bay National Wildlife Refuge, Virginia Beach, Virginia. Hatching success is the ratio of total number of hatchlings released to the total number of eggs produced, expressed as a percentage.

Nest construction date	Nest hatching date	Number of eggs produced	Number of eggs hatched	Number of infertile eggs	Number of hatchlings released	Hatching success (%)
14 Aug 1995	03 Nov 1995	84	81	3	79[a]	94
07 Aug 1996	25-26 Oct 1996	123	109[b]	10	109	88
09 Aug 1996	26-29 Oct 1996	138[c]	57	80	57	42

[a] Two hatchlings died prior to release.

[b] Four dead hatchlings were found in the nest.

[c] One egg was donated to the Virginia Institute of Marine Science (Gloucester, Virginia) for genetic study.

probability that nests will fail due to being seaward of (or on) the beach debris line, and hence be destroyed during high tide. (2) Given that part of the beach we monitor for nests is in a popular summer vacation area, nests potentially can be destroyed by beach landscaping activity and heavy foot traffic. (3) The beaches at BBNWR are open to wildlife- oriented activities (e.g., fishing, wildlife viewing, etc.). Additionally, special use permits allow some North Carolina residents to make limited vehicle trips on the beach. Both of these activities, neither of which can be eliminated, increase the probability of nest failure. (4) BBNWR is at the northern limit of the loggerhead's nesting range (DeGroot & Shaw, 1993), and hence few nests are produced on our beach. Therefore, our desire is to manage for high hatching success with the goal of increasing the number of nests on the beaches of BBNWR, to educate the public about the importance of reducing beach impacts, and to increase public awareness and participation in conservation efforts.

Moving turtle nests and the use of artificial incubation chambers for late nests has proven successful at BBNWR. If southern populations of loggerheads produce female- biased clutches, then enhancing the survival of loggerheads in more northern regions, which presumably produce more males, is an important step in the management of this species. Given the uncertainty of genetic diversity in Virginia loggerhead populations, limited knowledge of reproductive ecology in this region, and the importance and influence of multiple paternity in this species (Harry & Briscoe, 1988; Bollmer et al., 1999), management strategies should focus on enhancing survivorship of all nests in Virginia. If moving nests to protected locations, and artificially incubating late nests increases hatching success in our geographical area, then this program has contributed to the conservation and recovery of the threatened loggerhead.

ACKNOWLEDGMENTS

We thank R. Muller for his support. We also thank the seasonal and permanent staff at BBNWR who have taken part in our efforts. S. R. T. Williams and K. Phelps did much of the field work and provided technical support. Partial monetary support for loggerhead studies at BBNWR was provided by the U. S. Army Corps of Engineers, Norfolk, Virginia. We thank J. E. Lovich, R. P McIntosh, J. C. Mitchell, G. Zug, and several anonymous reviewers for their comments on earlier drafts of this manuscript.

Notice: The research described here was developed by the author (CLC) prior to his employment with the U.S. Environmental Protection Agency's Office of Research and Development. The manuscript has been subjected to EPA's administrative review but the conclusions drawn are solely those of the author. Mention of trade names or commercial products does not constitute endorsement or recommendation by EPA for use.

LITERATURE CITED

Blanck, C. E., & R. H. Sawyer. 1981. Hatchery practices in relation to early embryology of the loggerhead sea turtle, *Caretta caretta* (Linne). Journal of Experimental Marine Biology and Ecology 49: 163-177.

Bollmer, J. L., M. E. Irwin, J. P. Rieder, & P. G. Parker. 1999. Multiple paternity in loggerhead turtle clutches. Copeia 1999: 475-478.

Cross, C. L., J. B. Gallegos, F. G. James, & S. Williams. 1998. A new technique for artificially incubating loggerhead sea turtle eggs. Herpetological Review 29: 228-229.

DeGroot, K. A., & J. H. Shaw. 1993. Nesting activities by the loggerhead (*Caretta caretta*) at Back Bay National Wildlife Refuge, Virginia. Proceedings of the Oklahoma Academy of Sciences 73: 15-17.

Dodd, C. K, Jr. 1988. Synopsis of biological data on the loggerhead sea turtle *Caretta caretta* (Lineaus 1758). U. S. Fish and Wildlife Service Biological Report 88: 1-110.

Ehrhart, L. M. 1979. Analysis of reproductive characteristics of *Caretta caretta* in east-central Florida. American Zoologist 19: 955.

Ernst, C. H., R. W. Barbour, & J. E. Lovich. 1994. Turtles of the United States and Canada. Smithsonian Institution Press: Washington, D. C. 578 pp.

Frazer, N. B. 1992. Sea turtle conservation and halfway technology. Conservation Biology 6: 179-184.

Harry, J. L., & D. A. Briscoe. 1988. Multiple paternity in the loggerhead turtle (*Caretta caretta*). Journal of Heredity 79: 96-99.

Lutcavage, M., & J. A. Musick. 1985. Aspects of the biology of sea turtles in Virginia. Copeia 1985: 449-456.

Mrosovsky, N., & J. Provancha. 1989. Sex ratio of loggerhead sea turtles on a Florida beach. Canadian Journal of Zoology 67: 2533-2539.

Mrosovsky, N., & J. Provancha. 1992. Sex ratio of hatchling loggerhead sea turtles: Data and estimates from a 5-year study. Canadian Journal of Zoology 70: 530-538.

Mrosovsky, N., S. R. Hopkins-Murphy, & J. I. Richardson. 1984. Sex ratio of sea turtles: Seasonal changes. Science 225: 739-741.

Mrosovsky, N., & C. L. Yntema. 1980. Temperature dependence of sexual differentiation in sea turtles: Implications for conservation practices. Biological Conservation 18: 271-280.

Standora, E. A., & J. R. Spotila. 1985. Temperature dependent sex determination in sea turtles. Copeia 1985: 711-722.

Miscellanea

Book Reviews

Native Orchids of the Southern Appalachians by Stanley L. Bentley. 2000. University of North Carolina Press, Chapel Hill, North Carolina. 235 pp. Available for $39.95 (hardcover) or $24.95 (cloth) from UNC Press, P.O. Box 2288, Chapel Hill, NC, or purchase at http://www.uncpress.unc.edu.

It seems orchids have an unparalleled fascination with us. Not only are they beautiful, but their pollination mechanisms are often intricate and strange. Van der Pijl & Dodson (1966) begin their book with a quote from one of Darwin's letters, "I carefully described to Huxley the shooting out of the pollinia in *Catasetum*, and received for an answer, 'Do you really think I can believe all that?'." The often unusual manner of cross-pollination so effectively popularized by Darwin (1862), is, of course, related to the great diversity of forms in the largest family of flowering plants. Though the diversity is greatest where epiphytic forms abound in the tropical regions of the world, the predominately terrestrial forms of temperate regions also hold their spell over many a curious naturalist. This is what happened to Stanley L. Bentley, a native of Pulaski, Virginia, who recounts giving up his gun to capture his prey with a camera. One can only hope he wasn't as effective with his firearms! Not only are the photographs stunning, there are several other reasons why this is a book you may want for your shelf.

Native Orchids of the Southern Appalachians, as the name suggests, covers all the mountain counties of Virginia as well as adjoining portions of West Virginia, Kentucky, Tennessee, and North Carolina. The boundaries of the region of coverage are admittedly rather arbitrary to the north and south, but make good sense physiographically in the east-west direction. It includes all of the Blue Ridge, Ridge and Valley, Appalachian Plateau, Cumberland Plateau, and Unaka Mountain provinces. Limiting the range has the advantage for those of us who live within the region, of having virtually all of our native orchids included and being a manageable sized area with which the author is intimately acquainted. Fifty-two species are covered in the book, which includes one newly described species, *Corallorhiza bentleyi*, named for the author no less! One new hybrid and a new color form are also named, each commemorating orchid aficionados and friends of the author. Although the publication of new names in books of this nature is frowned upon in botanical circles, the criteria for naming have been met and will, hopefully, be adopted by other orchidologists.

Part 1 of *Native Orchids* spans 47 pages and covers a wide diversity of topics including a brief overview of the physiography of the region, a map identifying the counties of the southern Appalachian Mountains, and a discussion of the features that identify an orchid. When, where, and how to look for orchids is discussed and further aided by a table graphic that shows when each species may be found in flower. This rather simple but nicely shaded table is a useful feature for both the amateur and professional botanist. Several sections on special orchid places and orchid preservation have permitted the author to ramble a bit. A few nuggets of useful information may be worthy of recalling at a later time, but more than this, it's a little like sitting across the table and just talking orchids. The author's love for these plants and perhaps some of his idiosyncrasies show through in a delightfully refreshing way, something missing from most botanical books these days.

Part 2 is comprised of the photographs and individual species accounts. The photos are exquisite and may be the real selling point of the book. There are other orchid books with wonderful photos as well, and Bentley's book is, in my mind, as good as any. The colors are rich and true without exception. A particularly nice feature is that there are two or three photos of each species, one of which is an exceptionally good close-up. You see things here you may never have noticed in the wild before and it will certainly make you want to take a closer look the next time you see one of these beautiful creations. Certain species-specific features are often more plainly visible than you're accustomed to seeing in the wild. As an example, if you've ever wondered about the difference in shape of the orifice of the nectary between *Platanthera grandiflora* and *P. psychodes* (round vs. dumbbell-shaped), it suddenly becomes clear in Bentley's close-up photo.

Each species is discussed at some suitable length beginning with the meaning of the botanical name. Brief comments about the morphology, flower color, or other distinguishing features of the plant are most helpful. Where notable, historical and distributional information is included. An outline map (1.5" x 2.5") shows the distribution of each species by county. These small maps clearly and attractively display the distribution of each species. Published distribution records are supplemented by sight records of the author and various trusted and knowledgeable friends. Habitats are described in narrative form intermixed with other useful information regarding frequency, conservation concern, and personal experiences, to mention a few things. It was not the intent of the author for this work to be a compendium of information on the species included. However, an effort has been made to incorporate interesting and useful information in a readable manner, and the length of the species accounts varies accordingly. The book concludes with a short glossary, bibliography, and index. The index includes both common and scientific names.

Native Orchids of the Southern Appalachian Mountains is printed on high quality paper and is flexibly bound. The page size is 5.75" x 9.25" making it handy for thumbing through. The book just has a nice feel to it. The text is inset quite far allowing for a wide margin in which the species names are located for quick and easy reference. Photo captions are also located here and the distribution map extends into the margin in the lower corner. Full-page photos are "peppered" throughout. The use of space is so variable as to make the entire book interesting to look through. The graphic designers at UNC Press are to be commended for artfully presenting the author's exceptional work. It seems that nothing has been spared in this masterful production. You won't want to miss it!

Literatured Cited

Darwin, C. 1862. On the Various Contrivances by which British and Foreign Orchids are Fertilised by Insects. London.

Van der Pijl, L., & C. H. Dodson. 1969. Orchid Flowers, Their Pollination and Evolution. University of Miami Press, Coral Gables, FL. 214 pp.

Thomas F. Wieboldt
Massey Herbarium
Department of Biology
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061

Egg Dates for Virginia Birds by Roger B. Clapp. 1997. Virginia Avifauna No. 6. Virginia Society of Ornithology, Lynchburg, Virginia. 123 pp. Available for $10.00 from Virginia Society of Ornithology, 1230 Viewmont Drive, Evington, VA 24550-2006.

Egg Dates for Virginia Birds is a painstakingly researched compilation based on more than 100 years of accumulated records. This book is a valuable addition to the knowledge of Virginia's avifauna, and is a handy reference for all those questions about early and late nesting birds. The first book about birds of Virginia that included data based on nest records and egg collecting was published in 1913 (Bailey, 1913). J. J. Murray's (Murray, 1952) checklist owed much to this earlier work. Murray's checklist was then revised in 1979 (VSO, 1979) and updated again in 1987 (Kain, 1987). *Egg Dates for Virginia Birds* follows directly in this line, but is narrower in scope and deeper in research. Roger Clapp has not only done a remarkable job in tracing the origins of Bailey's dates, but has conducted extensive research into museum collections, unpublished notes, and written references, putting the published literature on Virginia breeding bird records on a solidly firm foundation. Early records have a way of being uncritically repeated in the literature. For example, a nesting of the Short-eared Owl *(Asio flammeus)* in the Coastal Plain reported in Bailey (1913) and repeated through Kain (1987), is rightly regarded by Roger Clapp as unsubstantiated after examining both Bailey's written account and egg catalog.

This book is an annotated list of known egg dates and related nesting data for the 218 known species of breeding birds of Virginia. Egg date information is provided for 195 of them, and the remaining 23 species for which there are no egg data are discussed with references. The number of records for each species varies from one for the Bobolink (*Dolichonyx oryzivorus)*, to as many as 27 for the Gray Catbird (*Dumetella carolinensis)*. Included for each species in columnar table format is information on dates, locality, nest specifics, observers, and references.

Early and late egg dates, if available, are listed for each of the three broad geographic provinces of the state, Coastal, Piedmont, and Mountain and Valley, with as many as five or six early or late records listed for each, but often fewer. The first column, Type of Record, indicates the geographical province and whether the record is early or late, and if it is the state record. The column Previous Record is not defined, but apparently refers to Kain (1987), and indicates the date from that volume which the present study supercedes. The Locality column gives the specifics on the geographical location as best as can be determined from the observer's records. Appendix 1 lists the corresponding county and USGS quadrangle where the location is found. These are not necessarily on the popular and widely available state DeLorme Atlas, so reference to the quadrangles may be needed if someone wants to track down actual field locations.

Definitions of abbreviations used in the Sources column can be difficult to track down in the book. For instance, sources for the Carolina Chickadee (*Poecile carolinensis)* include VAP, defined in Appendix 3, CES, an observer defined in Appendix 2, and R 23:47, a bibliographical definition defined on page seven in the introduction. If you do not already have a good idea of what the abbreviation points to, it can be frustrating to track it down, although I have not found any omissions.

A book such as this with a voluminous amount of information is bound to have a few errors. I found few typos; the late coastal date for the Prothonotary Warbler (*Protonotaria citrea)* listed as 15 July 1919, should be 15 July 1991. The references and gazetteer listings that I checked out were all properly listed.

Roger Clapp has done a highly commendable job, and Virginia is lucky to have someone to take on this formidable task. A book such as this is, of course, not the last word, but only a record of what is known as of the publication date. Species have already been added (e.g., Scissor-tailed Flycatcher *Tyrannus forficatus*), and early and late dates exceeded, sometimes greatly so (e.g., records for Killdeer *Charadrius vociferus* and American Robin *Turdus migratorius*). But that is the purpose of a book such as this, to give field workers the knowledge of what is known so that it can be added to. Anyone, professional or amateur, interested in the status of breeding birds in Virginia will want to own a copy.

Literature Cited

Bailey, H. 1913. The Birds of Virginia. Lynchburg, VA. 362 pp.

Kain, T. (ed.). 1987. Virginia's Birdlife: An Annotated Checklist. Virginia Society of Ornithology. 127 pp.

Murray, J. J. 1952. A Checklist of the Birds of Virginia. Virginia Society of Ornithology. 113 pp.

Virginia Society of Ornithology. 1979. Virginia's Birdlife: An Annotated Checklist. Virginia Avifauna No. 2. Virginia Society of Ornithology. 118 pp.

Paul Bedell
10120 Silverleaf Terrace
Richmond, Virginia 23236

Reports

1. President's Report

Elections for Vice President and two Councilors were held this spring. Barbara Abraham of Hampton University was elected Vice President. The Councilor seats required a run off election in accordance with our By Laws and this delayed announcement of the outcome. Paul Bedell of Richmond and Thomas J. McAvoy of Virginia Tech will join Joella Killian (continuing from previous years) as Councilors and members of the Executive Committee. Congratulations to all and thank you for your willingness to participate in governance of the Society.

We held our annual joint meeting with the Natural History & Biodiversity Section of the Virginia Academy of Science on May 24, 2001 at James Madison University. Eugene G. Maurakis (Chair) of the Science Museum of Virginia, John M. Kilpatrick (Secretary) of Virginia Tech, Jess W. Jones (Editor) of Virginia Tech and Ralph Eckerlin (Councilor) of Northern Virginia Community College were elected officers of the NHB Section of VAS. Nine papers, with authors representing James Madison University, Longwood College, North American Native Fishes Association, the University of Richmond, the Science Museum of Virginia, Utah State University, Virginia Commonwealth University, Virginia Museum of Natural History and Virginia Tech, were presented. The William S. Woolcott Best Student Paper Award was given to Jonathan Moore of VCU. He will receive a check for $100 from the VAS.

According to our (VNHS) Treasurer's report (Anne Lund - in absentia), we have $6377 (as of May 2, 2001). This amount is about $400 less that last year at this time but we remain financially stable. Anne also reported that as of May our paid membership stood at 120 (17 of which are institutions or libraries). This is down from last year's membership of 155. We will remind delinquent members to get their renewal checks in with the current issue of *Banisteria*.

The main item of business discussed was a request from the Virginia Museum of Natural History regarding funding of fellowships. Dr. Judith Winston (VMNH) informed us that the VMNH fellowships provide support of up to $1000 for a graduate student(s) engaged in collections-based research in the Commonwealth of Virginia. The fellowship may be used to support research in existing museum collections of specimens/objects from Virginia and/or fieldwork which results in the creation of a collection suitable for deposition in a museum. Dr. Winston (a VNHS member) stated that it would be great to have the VNHS co-sponsor one of these awards. Although attendance at our business meeting was sparse, there appeared to be universal agreement that, budget permitting, VNHS should pursue establishment of such an award. There was some discussion as to what form this award should take and the timing of applications. Since a number of the members of the VNHS are employed by institutions without a graduate program, it was suggested that we might offer an undergraduate fellowship. It was noted that the VAS will hold a fall meeting in 2001 specifically directed to undergraduate research and will announce at this meeting several undergraduate research awards in the amount of $500 each. It was suggested that the VNHS might join, not only with the VMNH, but also VAS (by using their fall meeting), in funding an undergraduate award in collections-based research with similar criteria as the VMNH graduate fellowship. There was general concurrence that the Executive Committee should pursue the feasibility of such an award, what form this award would take and other specifics such as applications, where, when, etc. I will query the Executive Committee on this matter and hope to report soon on the outcome.

As I look ahead to the coming years and think about possible initiatives for the VNHS there is one notable date that stands out. We are approaching the 400th anniversary of the founding of Jamestown (2007). This promises to be a big event in the Commonwealth and perhaps the Society should be thinking about an appropriate contribution to the festivities. On a much more immediate note I would urge all current members to invite your colleagues and friends, who are not yet members, to join the Virginia Natural History Society. The subscription to *Banisteria* (an excellent natural history periodical), included with each membership, alone should justify the cost of membership. Although I believe our membership is adequate to maintain the Society and the publication, there is strength in numbers. Participation at our spring meeting was sparse with only nine papers presented. Over the previous four years we have averaged almost 18 papers per meeting. Next year we will meet at Hampton University on or about May 23, 2002. I encourage you to attend and present a paper. Also, don't forget the opportunity for students to win a monetary award.

Respectfully submitted,
Werner Wieland, President

2. Secretary/Treasurer's Report

We have 120 memberships, 17 of which are institutions or libraries. These are both new and renewed memberships for 2001. This is not as high as we want for the year, but this is a good total in some ways considering that we have sent no additional reminders so far this year. We were successful in reminding these members to renew their membership with the society by sending them a notice about renewal and a return envelope in our mailing of *Banisteria* (#16), the second issue of the journal for 2000. (At the end of 2000, we had 155 members.)

As always, we encourage our active members to recruit members for the Society. A membership form is included with this mailing. Pass it on to a friend. If you were a member last year, and have not renewed your membership, you are receiving this journal with a reminder to submit your membership payment.

Our treasury presently holds $6,377 (as of May 2, 2001). The expenses for the publication and mailing of this issue of *Banisteria* (#17) will be subtracted from this amount.

We continue to be grateful to Hampden-Sydney College for support with the paperwork concerning our treasury. Our secretary, Beckie Smith, has done a good job of keeping our records of membership accurate, and she has prepared the address labels for all mailings.

Please submit all enquiries about membership in the Society or about past issues of *Banisteria* to: Dr. Anne Lund, Virginia Natural History Society, Box 62, Hampden-Sydney, Virginia 23943.

Respectfully submitted,
Anne Lund, Secretary/Treasurer

3. Editor's Report

The spring issue of *Banisteria* (# 17 - this issue) will be published later than usual this year largely due to the slow rates of manuscript submission and reviewer return. We have long been plagued with too few manuscripts and are wondering why people are not submitting their observations, reports, and theses to us. It is not a hard thing to do. Our job is to help you get manuscripts in shape for publication so that valuable natural history observations are not lost forever or remain buried in files. Publication of your observations means that they will be in the permanent scientific record and be useful to others. These same statements were in the last issue, and the previous issue, and other issues of the journal. It is obvious that we, the editors, are having the same old problems. So, why don't our members do more for our journal? We would like to know.

More material is needed to fill the fall issue of *Banisteria* (#18), so please submit your manuscripts, book reviews, or biographies soon.

Joe Mitchell and Steve Roble, Co-editors

4. Eighth Annual Meeting of the Virginia Natural History Society

The 8th annual meeting of the VNHS was held on May 24, 2001 at James Madison University, Harrisonburg, Virginia. *Banisteria* #18 will contain a list of titles of papers presented at this meeting.

Instructions for Contributors

Banisteria accepts manuscripts that contribute to the public and scientific knowledge of the natural history of Virginia. This publication is intended to be an outlet for the kind of information that is useful but would not be accepted in the mainstream journals. Information found in field notebooks and files that never made it into scientific journals is especially important. Manuscripts derived from natural history observations, small-scale field projects, distribution surveys and reviews, species inventories, reports for contracted environmental projects, and unpublished theses are especially desired. The focus of *Banisteria* is classical and therefore slanted toward organismal biology. Reviews of books relevant to Virginia's natural history and biographies of naturalists influential in this field are also welcomed by the editors. The journal also is suited for papers on the history of natural history as it pertains to Virginia.

To qualify for publication in *Banisteria*, the manuscript must pertain in some way to the flora, fauna, geology, geography or Native Americans of the Commonwealth. Papers focusing largely on projects conducted outside of the state will be considered only if there is a strong connection to Virginia. Papers may be full length or shorter contributions, and we are always looking for book reviews. There are no page charges and authors are not required to be members of the Virginia Natural History Society to submit manuscripts, although membership in VNHS is strongly encouraged. The editors will be happy to assist authors in their preparation of manuscripts. We would rather help get natural history information published for others to use than have it remain on the shelf or in someone's desk.

Manuscripts on vertebrates, history, biography, and material for the Miscellanea section (announcements, news of members, obituaries, etc.) should be sent to Joe Mitchell. Manuscripts on plants, invertebrates, and book reviews should be sent to Steve Roble. Papers on other topics can be submitted to either editor. Mitchell and Roble will serve as editors for each other's papers and an associate editor will be asked to serve as editor for those papers written jointly by the co-editors.

Manuscripts should be sent in duplicate to the appropriate co-editor (see previous paragraph), who will in turn seek one or two reviews. Authors should retain both the original typescript and figures until final acceptance for publication. Photocopies are adequate for review purposes.

Manuscripts must be written on one side of standard size paper (21.5 x 28 cm) using double spacing throughout. Words should not be hyphenated. Manuscripts should be arranged in the following order: **title, author's name, author's address, text, acknowledgments, literature cited, tables, figure legends, figures**. Long manuscripts should have standard sections, e.g., Materials and Methods, Results, and Discussion, although some papers may not be amenable to such division, and short manuscripts (<4-6 pages) need not have these sections. All pages should be numbered, including tables. The title should be concise but informative. It and the author's name and address should be centered at the top of the first page. The text should begin on the first page beneath the author's address. Use good judgment on arrangement of sections when other than the standard approach is necessary. Use italics or underlines for species' scientific names.

References: Use the following as a guide. **Do not abbreviate journal names**.

Journal article with 1 author:
Scott, D. 1986. Notes on the eastern hognose snake, *Heterodon platyrhinos* Latreille (Squamata: Colubridae), in a Virginia barrier island. Brimleyana 12: 51-55.

Journal article with 2 authors:
Tilley, S. C., & D. W. Tinkle. 1968. A reinterpretation of the reproductive cycle and demography of the salamander *Desmognathus ochrophaeus*. Copeia 1968: 299-303.

Journal article with 3+ authors:
Funderburg, J. B., P. Hertz, & W. M. Kerfoot. 1974. A range extension for the carpenter frog, *Rana virgatipes* Cope, in the Chesapeake Bay region. Bulletin of the Maryland Herpetological Society 10: 77-79.

Book:
Harris, L. D. 1984. The Fragmented Forest. University of Chicago Press, Chicago, IL. 211 pp.

Chapter in a book:
Gentry, A. H. 1986. Endemism in tropical versus temperate plant communities. Pp. 153-181 *In* M. Soule (ed.), Conservation Biology. Sinauer Associates, Inc., Sunderland, MA.

Report:
The Nature Conservancy. 1975. The preservation of natural diversity: A survey and recommendations. Report to the U.S. Department of Interior, Washington, DC. 189 pp. (include report series and number if present).

Thesis:
Riddick, M. B. 1973. Freshwater mussels of the Pamunkey River system, Virginia. Master's Thesis, Virginia Commonwealth University, Richmond, VA. 105 pp.

Tables: Each table should be typed on a separate sheet of paper, preferably using 10 point font. A legend for each table should follow the number and must be on the same page as the table. Ruled, horizontal lines should be avoided except at the top and bottom of the table. Remember that **each table must fit within a space of 6.5 x 8.5 inches**, and that reduction may cause loss of detail.

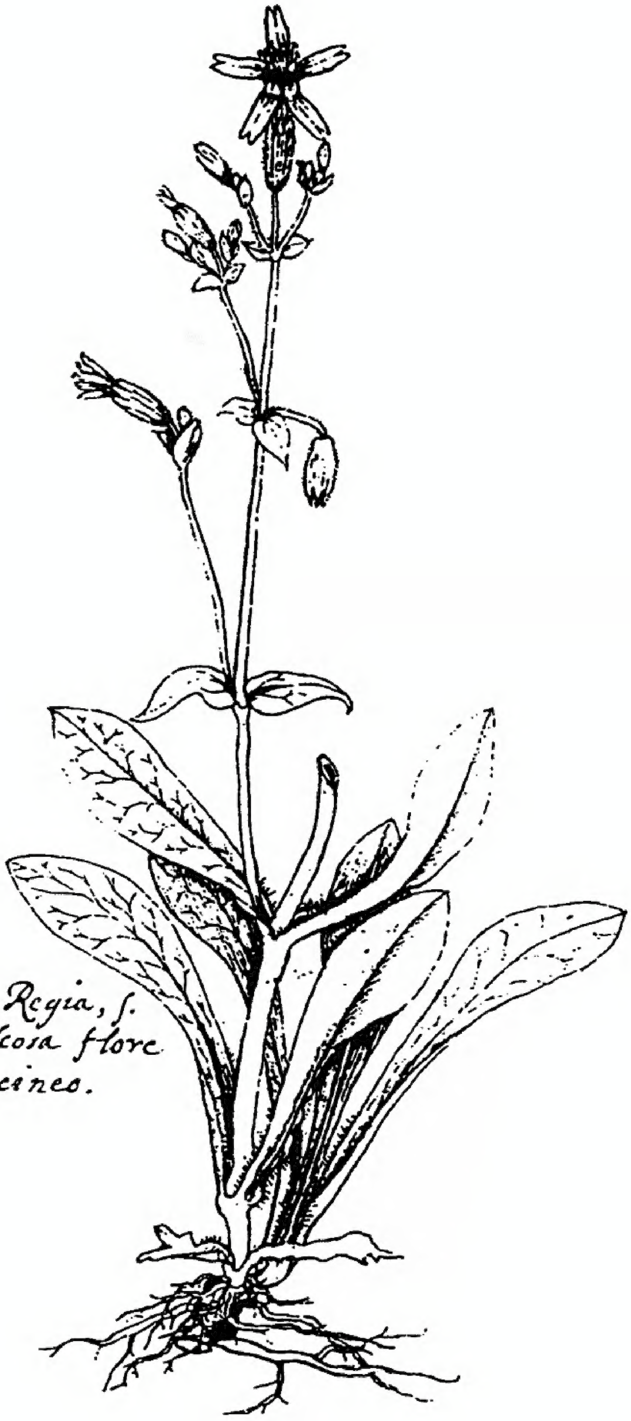
Figures: Black and white line drawings are acceptable for publication. They should be no more than twice the size of final publication size, and if several are assembled as a plate, keep the ratio of height to width consistent with the rectangular shape of the page. The back of each figure should be labeled with the author's name.

Photographs*:* *Banisteria* will accept high contrast black and white photographs. Submit at least 5 x 7 inch (12.5 x 17.5 cm) photos and mount them if possible. Remember that reduction to fit column or page width will cause loss of detail.

Abbreviations*:* The following common abbreviations are accepted in *Banisteria*: n (sample size), no. (number), SVL (snout-vent length; define on first usage), DBH (diameter at breast height), yr (years), mo (months), wk (weeks), h (hours), min (minutes), s (seconds), P (probability), df (degrees of freedom), SD and SE (standard deviation and standard error), ns (not significant), l (liter), g (gram), mm (millimeter), m (meter), km (kilometer), and C (degrees Celsius). Do not abbreviate "male" and "female", or dates, or undefined terms.

Electronic transfer of manuscripts: After a manuscript has been accepted for publication, one paper copy and an electronic copy on a 3.5 inch diskette should be sent to S. M. Roble. If possible, use IBM-compatible systems with Microsoft Word or Word Perfect. Please do not justify right-hand margins, and do not attempt to produce "camera-ready copy."

Reprints: Reprints are not provided. However, authors will be sent one printed copy of their formatted article to allow them or their institutions to prepare photocopies or electronic files for personal use or exchange purposes.



Muscipula Regia, ſ.
Lychnis viſcosa flore
amplo coccineo.